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Canadian Mining Institute

1905

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"The Institute as a body shall not be responsible for the statements or opinions advanced in the papers which may be read, or in the discussions which may take place at its meetings."—*By-Laws, par. xxxii.*

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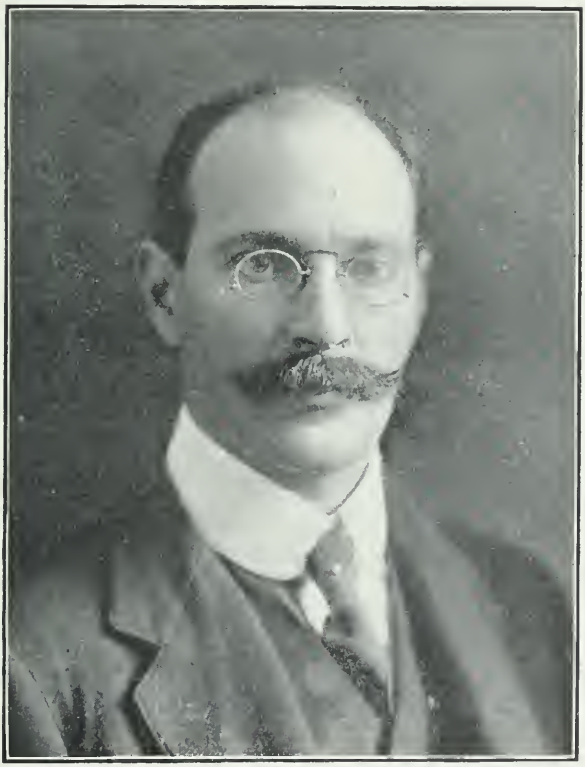

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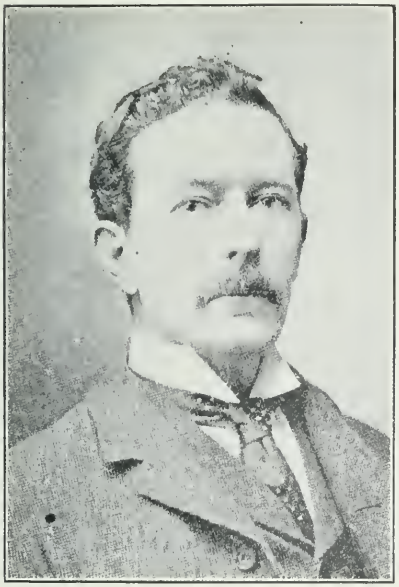

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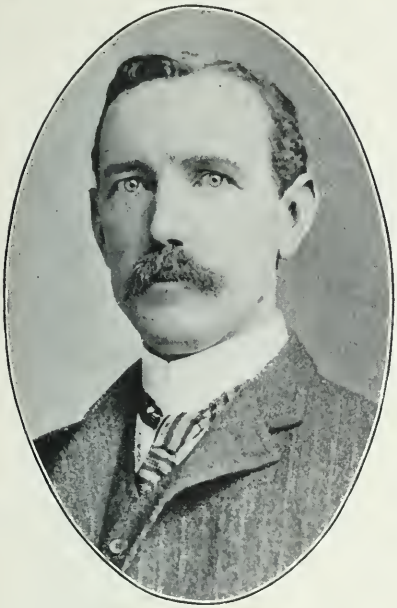

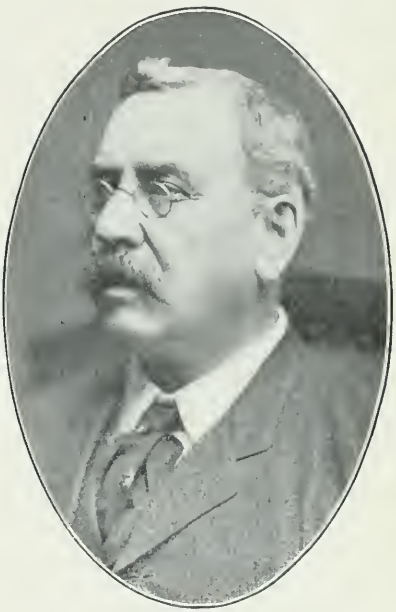

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JOURNAL OF THE CANADIAN MINING INSTITUTE, VOL. VIII.

Proceedings of the 7th Annual General Meeting held in Montreal, Que., March, 1905.

The Seventh Annual General Meeting of the Canadian Mining Institute was held at the Windsor Hotel, Montreal, on Wednesday, Thursday and Friday, the 1st, 2nd and 3rd of March, 1905.

The following members and guests signed the register of attendance:—

Fritz Cirkel, Montreal.
John Blue, Eustis, Que.
E. D. Ingall, Ottawa.
G. R. Mickle, Toronto.
F. Hobart, New York.
J. W. Evans, Deseronto, Ont.
J. C. Gwillim, Kingston.
S. Dillon-Mills, Toronto.
E. R. Faribault, Geol. Survey, Ottawa.
A. W. G. Wilson, Montreal.
J. Burley Smith, Montreal.
John E. Hardman, Montreal.
Eugene Coste, Toronto.
W. L. Goodwin, Kingston.
T. C. Walker, Toronto.
R. C. Purser, Windsor, Ont.
P. C. Coates, Toronto.
John H. Ryckman, Hamilton.
George S. Hanes, Blind River.
Eugene Haanel, Ottawa.
A. Stanfield, Montreal.
C. W. Knight, Kingston.
J. F. Black, Sudbury.
E. G. Stairs, Montreal.
Frank Adams, Montreal.
Thos. W. Gibson, Toronto.
J. Stevenson Brown, Montreal.
A. P. Low, Ottawa.
S. F. Kirkpatrick, Kingston.
Chas. W. Dickson, Kingston.
C. H. Taylor, Montreal.

D. Sloan, Kingston.
G. C. Bateman, Kingston.
S. L. Spofford, Lennoxville, Q.
J. A. Dresser, St. Henri de Montreal.
J. Obalski, Quebec.
D. B. Dowling, Ottawa.
A. E. Barlow, Ottawa.
Alfred C. Garde, Nelson, B.C.
Henry Ami, Ottawa.
B. Auzias-Turenne, Dawson.
D. D. Cairnes, Kingston.
H. J. Williams, Danville.
F. Philpott, Montreal.
E. L. Fraleck, Queensboro.
H. Macpherson, Kingston.
T. N. Speller, Pittsburg, Pa.
E. W. Gillman, Montreal.
A. W. Stevenson, Montreal.
John Bonsall Porter, Montreal.
Geo. R. Smith, Thetford.
J. B. Tyrrell, Dawson.
R. T. Hopper, Montreal.
W. J. Johnston, New York.

1ST SESSION—WEDNESDAY MORNING.

The members assembled at half-past ten on Wednesday morning, the meeting being called to order by the President, Mr. Eugene Coste, E.M., of Toronto, who welcomed the members and guests.

The minutes of the last annual general meeting, forming part of Vol. VII. of the Journal of the Institute, were taken as read, and approved.

The President then read the report of the Council for the year 1904-5. He stated at its conclusion that the President's gold medal had been awarded by the Council to Mr. C. W. Knight, for his paper on "Some Deposits in the Eastern Ontario Gold Belt."

REPORT OF THE COUNCIL, 1904-5.

The Council takes pleasure in submitting the following Annual Report to the members of the Institute, required by paragraph 22 of the by-laws of the Institute.

MEMBERSHIP.

A list of the members, as at the 1st of March, 1905, has been printed for distribution to the members.

The following table shows the membership by provinces and other countries as compared with previous years since the organization of the Institute.

COMPARATIVE STATEMENT SHOWING DISTRIBUTION OF MEMBERSHIP

AS AT 31ST DECEMBER, 1898-9-1900-1-2-3-4.

	1898	1899	1900	1901	1902	1903	1904
Nova Scotia	16	16	19	27	31	30	24
New Brunswick	2	1	2	2	1	1	1
Quebec	66	77	77	77	79	69	68
Ontario	44	66	91	83	107	108	103
British Columbia	42	65	72	67	72	68	55
Manitoba	..	..	..	..	2	2	1
Newfoundland	..	1	2	2	2	2	1
Alberta	5	5	5	6	6	7	10
Yukon	..	..	..	2	5	11	9
Great Britain	4	9	7	12	14	12	14
United States	11	17	26	30	36	36	36
Other countries	..	3	8	11	6	11	11
Students	2	15	14	12	92	78	52
Affiliated students	..	..	..	..	..	..	95
	192	227	323	331	453	435	480
Died during the year	2	4	4	4	2	3	3

The decline in the full membership shown for 1904-5 by the above table is more apparent than real, as the Council has struck off from the list this year a larger number of mem-

bers in arrears than usual. Some members of the Council, in fact, feel that none but members in good standing for the current year should participate in the voting and other privileges of membership, and the Council is considering the advisability of passing a resolution to that effect.

DECEASED MEMBERS.

The Council records with profound sorrow the deaths of Mr. B. T. A. Bell, of Ottawa, the first Secretary of the Institute; of Mr. Cornelius Shields, of Sault Ste. Marie; and of Mr. J. R. Gifford, of Choix, Sinaloa, Mexico.

The lamented death of our late secretary was recorded at our last annual meeting, but it is included again here as this is the first report of the Council to the Institute since we were deprived of his valuable services. The sudden death of Mr. Cornelius Shields was also a great loss to the Institute and to the country, as he had been for years creditably connected with large mining enterprises in Canada.

LIBRARY AND READING ROOM.

After the death of our late secretary, the library, which, as the members are aware, had been moved to Ottawa for the purpose of being under the immediate supervision of the secretary, was left unattended, and it was therefore thought advisable to remove it back to Montreal, designated in our charter as the headquarters of the Institute.

Suitable arrangements were made with Mr. Fritz Cirkel, M.E., a member of the Council of the Institute, to take charge and care of it, and to house it on the ground floor of 80, Stanley Street.

These premises were fitted up for the purpose by Mr. Cirkel, and are very centrally situated, and very convenient to the Windsor Hotel, which has always been the headquarters of the members when in Montreal.

The librarian, Mr. Cirkel, is preparing a new catalogue of all the books, pamphlets, periodicals and maps of the Insti-

tute, in order that the members may be able in the future to obtain a loan of any work of reference in the Institute's collection for a limited period by giving a receipt and surety for the value of the book or books loaned.

MEETINGS.

The Annual General Meeting was held in the City of Toronto on the 1st, 2nd and 3rd of March, 1904, and was considered by a great many who attended to have been one of the most successful meetings the Institute has had, notwithstanding the sad circumstances under which the members met, and which necessitated the cancellation of the annual banquet of the members and of the projected excursion to Niagara Falls. This meeting, unfortunately, was therefore not the complete success the Toronto members especially wished to make it, and on that account it will no doubt be thought advisable to select Toronto again as the place in which to hold another annual meeting.

Several meetings of the Council were held, as usual, during the year at Montreal and other places.

Two meetings of the Eastern Ontario Section were held in Kingston, in January and February, and a number of interesting papers were read and discussed.

PUBLICATIONS.

Thirty-three papers were read and discussed at the Toronto meeting, and these, with the detailed proceedings of the meeting, now form Volume VII. of the Journal of the Institute, which has just been issued to members in good standing.

Contrary to the previous practice, which had been to print an issue of between four and six hundred copies only, the Acting Secretary printed this year one thousand copies of Volume VII., and in addition also printed five hundred copies of each of the papers in separate form. This preliminary pamphlet edition was issued in August, 1904, and thus the members received early copies of all the papers presented at

the meeting, and of the discussions accompanying them. These pamphlets have also been largely in demand from outside sources, and one thousand extra copies of Mr. Kirby's paper were printed for the Rossland Board of Trade, and several hundred extra copies of some of the other papers were also printed for general distribution to the public.

The extra cost entailed in this larger issue of our papers and Journal has been very trifling compared with the advantages gained. In fact, the whole of the 1,500 copies and of several hundred extra copies of some of the papers were obtained complete from the printer for the sum of $2,021.27.

In later years, the extra copies of Volume VII. left in our library will become quite valuable; in the past the absolute exhaustion of our previous volumes has often been referred to in the reports of the Council or at meetings of the Institute, but this will not be the case any more, starting with Volume VII.

It will probably be found necessary at some early date in the future to reprint Volumes I. to VI. of our Journal, as absolutely no copies of the first five volumes are available, and only a very few of Volume VI.

STUDENTS' COMPETITION AND AWARDS.

Eight papers were submitted by student members at the Toronto annual meeting, 1904.

After receiving the reports of the committees of judges, the Council awarded the President's Medal to Mr. C. W. Knight, for his paper on "Some Deposits in the Eastern Ontario Gold Belt." This medal will be formally presented to Mr. Knight at the coming annual meeting.

The Council also awarded the three cash prizes of $25.00 each, as follows:—

In Mining—To Mr. E. J. Carlyle, for his paper on "The Pioneer Iron Mine of Ely, Minn."

In Geology—To Mr. E. T. Corkill, for his paper on "Mica."

In Metallurgy, etc.—To Mr. J. F. Hamilton, for his paper on "Oil Concentration."

The Council takes pleasure in congratulating the above gentlemen on the very creditable papers they have presented to the Institute.

TREASURER'S REPORT.

The audited statement of the treasurer is hereby submitted to the members in detail:—

TREASURER'S STATEMENT.

YEAR ENDING FEBRUARY 1ST, 1905.

RECEIPTS.

Balance from last year		$3,048 73
Subscriptions, 252 at $10.00	$2,520 00	
Student members, 7 at $2 00	14 00	
Affiliated student members, 83 at $1.00	83 00	
Arrears collected	134 00	
		2,751 00
Sale of publications		39 91
Sundries		87 41
Ontario Government Grant		300 00
Dominion Government Grant		3,000 00
		$9,227 05
Less—		
Disbursements, per statement		7,326 10
Balance on hand		$1,900 95

Audited and found correct.

GEORGE McDOUGALL,
Auditor.

SUMMARY STATEMENT.

SHOWING DISTRIBUTION OF DISBURSEMENTS TO THE VARIOUS WORK AND BUSINESS OF THE INSTITUTE.

Publications—		
Transactions	$3,582 05	
Postage and express	184 74	
		$3,766 79
Library—		
Rent	$445 25	
Removal	79 50	
Typewriter	60 00	
Insurance	3 50	
Sundries	280 57	
		868 82
Meetings—		
Reporting annual meeting	$100 00	
Sundry accounts	274 26	
Council meetings	245 54	
Deputations	170 45	
Advertising	25 00	
		815 25

Secretary's Office—		
Secretary's grant	$558 33	
Postage and telegrams	72 56	
Printing, stationery and sundries	225 11	
		856 00
Treasurer's Office—		
Treasurer's grant	$500 00	
Postage and telegrams	64 60	
Printing, stationery and sundries	106 69	
Bank charges on cheques and drafts	62 55	
Audit	10 00	
		743 84
Sundries—		
Advertising	$ 50 00	
Prizes	100 25	
Safe	50 00	
Wreath	15 50	
Legal expenses	35 00	
Clerical work	25 00	
		275 40
		$7,326 10

Audited and found correct.

GEORGE McDOUGALL,
Auditor.

Montreal, February 1st, 1905.

In presenting the financial statement for the year just closed, it may not be out of place to furnish you with a statement which will in some measure show the financial growth of the Institute during the five years in which I have had the honor to administer its funds, viz., since March, 1900.

The balance at the credit of the Institute at the close of each financial year was as follows:—

Year		
1900		$ 484 87
1901		630 61
1902		957 40
1903		1,682 49
1904	$3,048 73	
Less liabilities	1,139 15	
		1,909 58
1905	$1,900 95	
Less liabilities	912 22	
		988 73

Respectfully submitted,

J. STEVENSON BROWN,
Treasurer.

NEW MEMBERS.

The following new members were elected:—

W. H. Boyd, Geological Survey, Ottawa, Ont.

Geo. A. Young, Geological Survey, Ottawa, Ont.

Jos. Keele, Geological Survey, Ottawa, Ont.

Alex. Hamfield, Union Club, Victoria, B.C.

J. M. Turnbull, C. P. R. Mining Dept., Trail, B.C.

Dr. C. W. Dickson, School of Mining, Kingston, Ont.

Dr. W. A. Parks, University of Toronto, Toronto, Ont.

Jas. White, Geographer, Dept. of Interior, Ottawa, Ont.

Alex. Smith, Los Reyes Gold Mining Co., Oaxaca, Mexico.

Augustus Trudo, 43 Tremont Street, Boston, Mass.

D. H. Browne, Canadian Copper Co., 43 Exchange Place, New York, N.Y.

Lewis Stockett, Gen. Mgr. Pacific Coal Co., Limited, Bankhead, Alta.

Geo. A. Revell, M.E., Turbine, Ont.

L. Morrison, 106 Shuter Street, Toronto, Ont.

D. B. Dowling, Geological Survey, Ottawa, Ont.

John J. Penhale, Sherbrooke, Que.

Walter R. Kerr, Black Lake, Que.

Beaumont Shepherd, Black Lake, Que.

J. R. Rand, Rrand Drill Co., 11 Broadway, New York, N.Y.

W. J. Johnston, 120 Liberty Street, New York, N.Y.

J. B. D. Legare, Quebec, Que.

Noel A. Wallinger, Fort Steele, B.C.

On motion, the report of the Council was adopted.

APPOINTMENT OF SCRUTINEERS.

On the motion of Mr. Geo. Drummond, seconded by Dr. Goodwin, Messrs. A. W. Stevenson, A. P. Low and Prof. W. G. Miller* were appointed scrutineers of the annual vote for the election of officers. It was announced by the President

* Subsequently Mr. F. Hobart was requested to act in the place of Prof. Miller, who was engaged on special committee work.

that the voting would close on Friday noon, and that the report of the scrutineers would be presented during the Friday afternoon session.

Mr. John E. Hardman presented an invitation to the members from the Allis-Chalmers-Bullock Co. to visit their works, and Dr. Porter also tendered a like invitation to the members from the McGill University to visit that institution, and also invited the members, on behalf of the Canadian Society of Civil Engineers, to make use of their rooms in their building on Dorchester Street during the meetings.

APPOINTMENT OF COMMITTEE ON BY-LAWS.

The following members were appointed to form a committee for the revision of the by-laws:—Messrs. A. C. Garde, J. M. Clark, K.C., J. Stevenson Brown, T. W. Gibson, C. Fergie, Prof. Miller, Dr. A. E. Barlow and Dr. J. B. Porter. The committee was instructed to report at the Friday morning session.

Mr. Ingall—Before that subject is left, I would like to ask some of the gentlemen present to enlighten me on a point. We have, as an Institute, passed resolutions here in Montreal on subjects of national importance, and it has always struck me that it was unfortunate that when such important matters were submitted the feeling of the whole membership could not be obtained. If this could be done on important matters, would it not be worth considering how to do it?

The President—There is in the proposed new by-laws a way to bring this about,—that is, a consultation of the members of the Institute from one end of the country to the other. For instance, if the question of establishing branches is decided upon, and these are established, then any important question would be submitted to the chairman of each branch, and he would ascertain the opinion of the members of the branch, and by referring to the opinion of the different branches we would have the full opinion of the whole membership. I think it would meet the point in view very well.

Mr. J. Stevenson Brown—Our membership is so widely distributed, from British Columbia to Nova Scotia, the Transvaal, Honolulu and the South American Republics, that it would be almost impossible to work the Institute except from a central point, where you can get a good representation of the members.

Mr. Ingall—In the case of the by-laws, you are doing exactly what I would suggest in all important cases, viz., that they should be submitted to the members at large for their suggestions. I think we should insist upon a referendum of the whole Institute in important cases.

The President—Of course, we have a few members in foreign countries, but we have a great many more at home, so that if we had in each case the full opinion of the members from the different provinces on an important matter it would certainly help the Institute to act as a whole, in unison, and with more power. The united work of the members throughout the whole country is a very desirable step to bring about, and I think that the suggestion of forming branches will fill that want better than anything else.

MINING STATISTICS.

Mr. Ingall, in laying on the table the Summary Annual Report of the Mining Statistics of Canada, said:—I only wish to explain with regard to this report that we had to rush it through the press in a very great hurry, and you will find some clerical errors.

The President—I congratulate Mr. Ingall on his usual promptitude in bringing out this report at this early date, and just in time for our meeting. I may add that we are always very glad to get the report, but to get it every year at our annual meeting is doubly satisfactory.

The meeting adjourned.

SECOND SESSION—WEDNESDAY AFTERNOON.

The meeting was called to order at 3.00 p.m., Mr. Coste, the President, in the chair.

The President—Before proceeding, I have to say that I have just received from the Engineers' Club, of Montreal, an invitation to the members to make use of their rooms during the several days of the meetings. We all feel grateful for the invitation.

Dr. Goodwin—I think, Mr. Chairman, that some formal reply should be sent to the Allis-Chalmers-Bullock Co., expressing our regrets that the arrangements to visit their works should have miscarried, because the invitation was couched in such terms that would indicate that the company had taken a good deal of trouble to entertain us. I would move that the secretary be instructed to send a formal reply expressing our regret that the arrangements were miscarried, and that we are not able to accept the invitation.

The motion was carried.

ANNUAL DINNER.

After some little discussion whether the members should hold their usual annual dinner on Friday night, or whether they should have a smoking concert, or go in a body to the theatre, it was decided to have a smoking concert in the Windsor Hotel on Friday night.

The President—I have now very much pleasure in welcoming you all to this, our Seventh Annual Meeting, and to declare that the sessions for the reading of papers presented by the members are now opened.

The following papers were read and discussed:—

The Goldfield District, Nevada.* By Mr. E. P. Jennings, M.E., of Salt Lake City, Utah.

Bornite Ores of British Columbia and the Yukon Territory. By Mr. Wm. M. Brewer, M.E., of Victoria, B.C.

The Bedrock of the Gilbert River Goldfields, Quebec. By Mr. Jno. A. Dresser, M.A.

A Note on the Varieties of Serpentine in Southeastern Quebec. By Mr. Jno. A. Dresser, M.A.

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* The discussions on each paper will be found in this volume, following the papers to which they refer.

On the Need of a Provincial Museum in Ontario. By Dr. W. A. Parks, of Toronto, Ont.

The following papers were read by titles:—

The Advantages of combining Topographical with Geological Surveying in Unexplored Regions. By Dr. Robt. Bell, Ottawa, Ont.

Crude Petroleum and its Application as Fuel for Industrial Operations in the Hawaiian Islands. By J. N. S. Williams, C.E. & M.E., Puunene, Mauri, T. H.

On the Carboniferous of New Brunswick. By Dr. Henry M. Ami, Ottawa, Ont.

On Canadian Mica Mines. By E. T. Corkill, Toronto, Ont.

The meeting then adjourned.

THIRD SESSION—WEDNESDAY EVENING.

The members re-assembled at eight o'clock, the President, Mr. Coste, in the chair.

PRESIDENTIAL ADDRESS.

The President, Mr. Eugene Coste, then presented his address, as follows:—

"I take great pleasure in welcoming the members of the Canadian Mining Institute and their friends to this, our Seventh Annual General Meeting.

We have a very long programme of papers, of which, in my capacity as Acting Secretary, I must confess I am proud, and therefore I will detain you only a few moments with some remarks of general interest to our Institute.

That Canada is to-day already one of the great mining countries of the world is proved and admitted; that untold wealth of mineral resources still remain untouched in many parts of our vast undeveloped country is also fully recognized by our mining engineers and geologists, and by many others who have studied the question.

Could we not, all of us of the Canadian Mining Institute, the only incorporated Institute representing the mining men of the whole country, do more than we are doing to hasten a more rapid and healthy development and progress of this im-

mense mineral wealth of Canada? I have no hesitation in saying yes, we can do much more, and it is our duty to do it; our duty to ourselves; our duty to our beloved profession and industry; our duty to our great country. We are already a strong organization of some 500 members, and as I have reviewed it in my presidential address of last year at the Annual Meeting in Toronto, we have done a great deal in the past, but we can do and must do much more in the future.

Our country is now growing very rapidly—only the other day it was announced in Parliament by the Rt. Hon. the Premier that the North-West Territories were about to become Provinces of the Dominion—millions of dollars will shortly be spent in constructing railways through vast new stretches of our country, and many opportunities to open and develop new mining districts will thus be presented to all of us. Thus the problems confronting us in our mining profession and industry, whether scientific, economic, of legislation, of transportation, of treatment, or of any other nature, will soon multiply even more rapidly, and we must be ready to carefully consider and overcome all these problems and difficulties. Our mining interests have shown considerable expansion of late, and as an instance of it we have this year on our programme not less than 50 papers, almost every one of them on different subjects, and it is impossible for us to give to all these papers the necessary attention and discussion at this, our annual meeting. We are outgrowing our old clothes and we must cut our next suit on larger and broader lines. Many of the mining problems of the future will no doubt be settled directly and individually by some of us, but we can only hope to successfully master the many other questions and responsibilities which individual enterprise or energy alone will fail to solve or fulfil, by uniting still more firmly on a broader basis. "Union is Strength," and in my opinion the time has come for the members of the Canadian Mining Institute to adopt such changes in the Constitution and By-Laws of the Institute as will conduce to these results. You will be asked to consider suggestions with this end in view.

The Constitution or By-laws of any Institute or Society is of course the final guide and mainstay of it, and once a provision or rule is adopted and placed there the officers of that Institute or Society have then the necessary machinery to work with and the power to put this machinery in motion. It only remains for them by the exercise of zeal and intelligence to provide for its satisfactory operation.

These necessary changes or additions to our present machinery, as I propose them, will be found at length in the set of proposed new by-laws, copies of which I have sent to every member, but briefly stated they are:

(a) A larger representation of the members on our Board or Council of the Institute.

(b) The formation of strong branches of the Institute in the different provinces and in some of the important mining districts of the country.

Those who have taken an active part in the affairs of the Institute in the past are a unit, I believe, with me in admitting that it has been very often next to impossible to have a good representative meeting of the Board or Council of the Institute as at present constituted, with 12 or 13 members of it, or about one-half belonging to British Columbia and Nova Scotia. The gentlemen from these provinces are so far away that they can hardly ever attend the Council meetings, and as at present organized, one-half of our Council is practically unavailable to us, while on the other hand, we, the other half, are not the help to them that we should be. Thus only a very few of our Quebec and Ontario members have in the past actively participated in the management of the work of the Institute. This state of affairs is not broad enough and is not conducive to our acquiring a thorough knowledge of or to our giving the necessary attention to the many questions and problems affecting at all times the mining industries in the different provinces or districts of our vast country. Nor is it promoting the mutual help and intercourse among the members, which is one of the most important objects and missions of our Institute.

I submit, therefore, that in the best interests of the Institute we should now re-organize matters in order that in the future a good many more members from all over the country would in some way join the few who alone have acted in the past, and would become in common with them active thinkers, advisers and managers in all the affairs and objects of the Institute.

It will readily be seen that the above proposed changes or additions to our by-laws will accomplish this, not only by enabling more of us to meet in Council in Montreal, Toronto, and other places in the central part of the country as often as necessary, but also by means of branches we shall be in constant communication and interchange of ideas with members residing in the outlying districts. These, in the meetings of their branches, which can be held several times a year if necessary, will bring up and discuss all the interesting subjects connected in any way with their local mining interests and industries, and their chairmen, secretaries and full organizations will always be in touch with the central organization. Thereby the necessary activity and life will run through the Canadian Mining Institute from Yukon to Cape Breton, together with the necessary spirit of mutual help and unanimity of purpose so essential to permanent achievements.

As I expect that this subject will be fully discussed during the present meeting, I do not propose to deal at length with it now, but permit me in closing these few remarks on this important matter to give you an instance of what other Canadians have done with a similar organization to the one I advocate for the Greater Canadian Mining Institute. I refer to the Canadian Manufacturers' Association.

This is what Mr. R. J. Younge, the General Secretary of that Association, stated in his address at their annual meeting in this city, last September:

"Four years ago the Canadian Manufacturers' Association was largely a provincial organization, with one office and less than 200 members. To-day we number 1,500 members (in every

Province in the Dominion), with 6 branch offices and 13 sections, and we combine in our organization active committees whose functions cover the consideration of every important question affecting the manufacturing industries of Canada. . . . . At the head office five officers give their whole time to the work of the Association, and including the Branch Secretaries, the salaried employees of the organization are twenty in number, as compared with three or four years ago."

The Treasurer, Mr. George Booth, at the same meeting, stated:

"It is most gratifying to report also that after extending our operations and largely increasing our expenses, the treasury contains the largest balance in the history of the organization. . . . . The fees received during the year amount to $17,825, or more than six times the receipts of four years ago, and almost double the receipts from the same source last year."

In a letter Mr. Younge, the General Secretary, addressed to me some time ago, he was kind enough to give me the following outlines of the organization of the Canadian Manufacturers' Association:

"The Executive Council consists of 100 representatives from all parts of Canada, elected at the annual meeting on the per capita basis of one for every fifteen members.

"The great volume of work in the Association is performed by the standing committees. These consist of ten members each, with power to add to their number, and their functions cover the consideration of any and every question which interests the members of the Association. These committees meet generally every month and report to the Executive Council.

"Local branches are organized in leading Canadian centres and are given authority, under the Constitution and By-laws, to deal finally with any local question. Representations with regard to general questions are dealt with merely by recommendations, which are forwarded to the Executive Council for final action.

"Trade sections are also organized representing the leading

firms in their respective branches of industry throughout Canada. These meet for the discussion of trade matters, etc., as the occasion may demand."

The above example from a great Canadian Association is inspiring, and to my mind worth emulating. It shows what a Greater Canadian Mining Institute could do.

I now, gentlemen, take pleasure in declaring the Sessions of our Seventh Annual Meeting open for the reading and discussion of the papers presented by our members." (Applause.)

A telegram from Mr. Charles Fergie, of Nova Scotia, past president of the Institute, regretting very much his inability to be present, was read to the meeting by Mr. J. Stevenson Brown.

The following papers were read by the authors, who were accorded a hearty vote of thanks:—

Artesian and Other Deep Wells on the Island of Montreal. By Dr. F. D. Adams, McGill University, Montreal, Que.

The Value of Undeveloped Mining Claims. By Prof. G. R. Mickle, School of Practical Science, Toronto, Ont.

On Canadian Metallurgical Products for the Far East. By Mr. F. Hobart, M.E., of New York, N.Y.

The following papers were read by title:—

Notes on Concrete. By R. W. Leonard, C.E., St. Catharines, Ont.

On Electric Smelting of Zinc Ores. By F. T. Snyder, Oak Park, Ill.

The Possibilities of Steel Manufacture in British Columbia. By Wm. Blakemore, M.E., Nelson, B.C.

The meeting then adjourned.

FOURTH SESSION—THURSDAY MORNING (STUDENTS' SESSION).

The members re-assembled at ten o'clock, the President, Mr. Coste, in the chair.

The President—I extend the welcome of the Institute to the Students this morning. We always like to have a good

attendance of students at our annual meetings, as they, the younger generation, are the engineers of the future, and our vast country will need many good ones.

The following papers were read:—

Prospecting in Western Canada. By Mr. D. D. Cairns, Queen's University, Kingston, Ont.

Mine Surveying as carried on at the Centre Star Mine, Rossland, B.C. By Mr. H. L. Cole, McGill University, Montreal.

Notes on Graphite, Its Occurrence, Uses and Production. By Mr. G. C. Bateman, Queen's University, Kingston, Ont.

Drilling for Oil in the Petrolia Field, Ont. By. Mr. G. P. Stirrett, School of Practical Science, Toronto, Ont.

Chlorodizing Treatment of Nickel Ores. By Mr. F. N. Rutherford, School of Practical Science, Toronto, Ont.

The following papers were read by title:—

Notes on Mining in the Slocan, B.C. By D. Sloan, Queen's University, Kingston, Ont.

Solubility of Cobalt-Nickel Ores in Ammonia. By G. S. Hanes, School of Practical Science, Toronto, Ont.

Notes on Reverberatory Furnace Smelting at Anaconda. By A. McL. Hamilton, McGill University, Montreal.

Notes on Mining in the Centre Star and War Eagle Mines, Rossland, B.C. By G. C. Bateman, Queen's University, Kingston, Ont.

Dr. Ami—I should like to state that I think it a source of real pleasure to listen to such good papers by student members. It shows a great deal of activity and well-directed studies in our schools and universities where mining and allied subjects are taught, and the Institute has certainly taken a step in the right direction in presenting prizes for these papers to the men who are, in the future, to look after our mineral resources. We need a great many more mining engineers to tackle the vast mineral resources of Canada.

The meeting then adjourned.

FIFTH SESSION—THURSDAY AFTERNOON.

The members re-assembled on Thursday afternoon at three o'clock, the President in the chair.

The following paper was read and discussed:—

The Platinum Metals in Other Sources than Placers. By Dr. C. W. Dickson, Kingston, Ont.

In presenting this paper, Dr. Dickson said: "As you are aware, platinum has been creating a good deal of interest, and a number of important papers have been issued on the subject. Prof. Kemp, of Columbia, has issued a paper lately in which he deals with the sources of platinum in the mother rock. While I was revising this paper I got a paper from our own Geological Survey on the same subject. I hope the few points I have brought out will be of interest to some of our mining men."

The President then read a letter from the secretary of the American Institute of Mining Engineers, enquiring for copies of the Journals of the Institute, which, the letter stated, were greatly in demand.

Mr. J. Stevenson Brown, Dr. Goodwin and Mr. Cirkel, in a short discussion which followed, urged the advisability of printing the back volumes of the Journal, which were quite out of print and yet in considerable demand.

The President stated that the Council would, no doubt, soon consider this matter. He estimated that it would cost about $3,000 to secure a reprint of 1,000 copies of the back volumes of the Journal of the Institute.

The reading and discussion of papers was then continued, as follows:—

The Stratigraphy of the Cascade Coal Basin. By Mr. D. B. Dowling, of the Geological Survey, Ottawa, Ont.

On Bankhead Coal Mines. By Mr. C. M. Henretta, M.E., Bankhead, Alta.

Notes on the Life History of Coal Seams. By Prof. J. C. Gwillim, Kingston, Ont.

On Mining Statistics. By Mr. F. Hobart, New York, N.Y.

Uniform Mining Statistics in Canada. By Mr. Eugene Coste, E.M., Toronto, Ont.

The following papers were read by title:—

On Mining Laws. By J. M. Clark, K.C., Toronto, Ont.

A Correction in the Classification of our Gold Formation. By. F. Hille, M.E., Port Arthur, Ont.

The Economical Treatment of Sulphide Ores. By C. B. Jackes, Toronto, Ont.

The meeting then adjourned.

SIXTH SESSION—THURSDAY EVENING.

The members re-assembled on Thursday evening at eight o'clock, in accordance with a special invitation, at the building of the Canadian Society of Civil Engineers, Dorchester Street.

After the reading and discussion of a paper on Electric Smelting, by Dr. Eugene Haanel, of Ottawa, the President's Gold Medal was presented to Mr. C. W. Knight, for his paper, submitted for competition in 1904, entitled, "Some Deposits in the Ontario Gold Belt."

Mr. J. Obalski then read his paper on "A New Mining District in the North of the Province of Quebec," which was followed by an interesting discussion.

Mr. James White, Geographer, Ottawa, Ont., exhibited some rare old maps, both from his private collection and from the Library of the Department of the Interior, and also a number of modern maps, demonstrating the advances and character of the work now being done by the Department

Referring to an opinion advanced by Mr. White in the course of his remarks, Dr. H. M. Ami, said: "The question of ownership or possession of the vast territories in the District of Franklin is of considerable importance, and it is well that Mr. White has brought this matter before the Institute—one that certainly deserves our attention on account of the numerous and contradictory reports that have recently gone abroad. We must all be agreed that when the transfer was made by Great Britain of all her possessions in British North

America to Canada to become part of the Dominion of Canada, I think that there is no doubt that the whole of these possessions which we claim were British. It would be interesting to have the opinion of the Privy Council of England as to what they really included in the terms of the transfer of the islands, possessions, and territories of the North; and to ascertain whether they did not actually mean all the islands indicated within the area of the red line on the map before us, prepared by Mr. White."

Mr. A. P. Low, of the Geological Survey, Ottawa, who was in command of the Dominion Government Arctic Exploration, and had recently returned, having wintered in the Arctic, delivered an interesting address, illustrated by lantern slides, "On the Mining Possibilities of Arctic Canada."

In moving a vote of thanks to the lecturer, the President said: "Of course, Mr. Low told us a big—I will not say fish—story, as we have to believe everything the Commander tells us, but five thousand pounds of fish in an hour and a half is, however, such a tremendous catch that if it was not told by Mr. Low, we would surely only accept it *cum grano*."

Mr. Low—We have been talking about coal fields to-day. We have very large coal fields in the North. There is also a mica mine there which is now worked in connection with a whaling outfit. There is also a slight indication of copper along the east side of Baffin's Land. These immense coal fields in that region will, however, never be of use until the climate changes, and it is changing very slowly; five or ten thousand years from now, when they are available, perhaps all the other coal mines will be exhausted, and Canada will then have a coal monopoly of her own. Our business in the North was to go as far as white men had gone, and to take formal possession of these lands on behalf of Canada.

The President—I think that if they had been instructed to go to the North Pole, Mr. Low would have carried out his instructions.

The meeting then adjourned.

SEVENTH SESSION—FRIDAY MORNING.

The members re-assembled on Friday morning, March 3rd, at half-past ten o'clock, the President in the chair.

The President—I suppose our first business had better be the proposed changes in the by-laws of the Institute. It is certainly very important that we should get a good set of by-laws. I will ask the committee to bring in its report on this subject.

Prof. Miller—As convener of this committee I have to report that we have prepared and drafted a set of by-laws, which I would ask Dr. Porter to present, as Dr. Porter has acted as secretary of the committee. I wish to add that the committee has been unanimous on most points, but on one or two points I think there was probably a little difference of opinion, and we compromised on some of these, as we have to do in most cases of the kind. I think it is not necessary for me to say much more, except that I think I am voicing the sentiments of all other members of the committee when I say that we are all very much indebted to Dr. Porter for the work he has done on this committee. I think it was a very happy suggestion of Mr. Drummond's that Dr. Porter should be a member of this committee. I sympathize with Dr. Porter. For the last two days he has been tied down, and has not been free to attend the meetings. For my part, I feel under a very great debt of gratitude to him for the work he has done.

The report was then read, clause by clause, and the by-laws, as finally amended, were adopted, as follows:

BY-LAWS OF THE CANADIAN MINING INSTITUTE.

SEC. I.—MEMBERSHIP.

Par. I.—Members shall be persons engaged in the direction and operation of mining and metallurgical works, mining engineers, geologists, metallurgists, chemists, and such other persons as the Council may decide are eligible through connection with mining affairs.

Par. II.—Student members shall include persons under the age of twenty-five years who are qualifying themselves for the profession of mining or metallurgical engineering, students in pure or applied science in any university or technical school in the Dominion, and such other persons, up to the age of twenty-five years, who shall be engaged as apprentices or assistants in mining, metallurgical or geological work, or who may desire to participate in the benefits of the meetings, library, and publications of the Institute. Student members shall be eligible for election as members after graduation. Student members shall not be entitled to vote or to hold office.

Par. III.—Honorary members shall be persons who have distinguished themselves by their technical or scientific attainments, or persons eminent in the development of the mineral industry.

Par. IV.—The Director or Acting-Director of the Geological Survey of Canada, and the Superintendent of Mines of the Dominion, are ex-officio honorary members of the Institute.

Par. V.—The Technical Officers of the Geological Survey of Canada, who are in charge of Field Parties, are ex-officio members of the Institute.

SEC. II.—ELECTION OF MEMBERS.

Par. VI.—Applicants for membership shall be proposed in writing by two members, and shall fill in and sign an application according to Form A in the appendix. This application shall be laid before the Council, which may communicate with the endorsers and shall have power to elect or reject by vote of the members present. When the proposed candidate is elected, the Secretary shall give him notice thereof, and on payment of his dues for the year he shall become a member.

Par. VII.—Applicants for student membership shall be proposed in writing by two members, and shall fill in and sign an application in Form A, and if elected, by vote of the members present at a meeting of the Council, shall become student

members upon payment of the dues specified in Section III., Paragraph XI.

Par. VIII.—Each person proposed as an honorary member shall be recommended by the Council and elected by a two-thirds vote cast at a regular meeting of the Institute, his name having previously been sent out by letter to each member.

Par. IX.—Any member may be removed from the list of members for cause, on the recommendation of the Council, by a two-thirds vote of the members voting at a regular meeting of the Institute, but only after thirty days' notice shall have been sent to each member.

SEC. III.—SUBSCRIPTIONS.

Par. X.—The annual subscription from members shall be ten dollars, payable in advance, on the first day of February, in each year. Subscriptions remaining unpaid on April first, in each year, may be subject to sight draft made by the Treasurer.

Par. XI.—Student members, except as provided in Paragraph XII, shall pay two dollars per year in advance on the first day of February in each year.

Par. XII.—Any properly constituted society connected with a Canadian university, mining school or technical school may, with the approval of the Council, become affiliated with the Institute, and the students comprising such society shall then have all the privileges of student membership on payment by such society, annually in advance, on the first day of February in each year, of an amount equivalent to one dollar per head of its membership, and shall be known as affiliated student members.

Par. XIII.—Members in arrears for two years shall be considered as not in good standing and shall not be entitled to vote, and their names may be removed from the list of members by vote of the Council.

SEC. IV.—OFFICERS AND COUNCIL.

Par. XIV.—The affairs and business of the Institute shall be managed and controlled by an elected Board, to be called "The Council," which shall comprise:—

(a) A President.
(b) Four Vice-Presidents.
(c) Councillors as specified in Paragraph XXI.
(d) Past Presidents of the Institute as specified in Paragraph XVII.
(e) A Secretary.
(f) A Treasurer.

Par. XV.—At each annual meeting there shall be elected a President, two Vice-Presidents, one-half of the Councillors, a Secretary and a Treasurer.

Par. XVI.—The President shall be elected for one year, but shall be eligible for a second year.

Par. XVII.—The three last past Presidents of the Institute shall be ex-officio members of the Council, provided they remain members of the Institute in good standing.

Par. XVIII.—The President shall take the chair at all meetings of the Institute and Council at which he may be present, and shall regulate and direct proceedings in accordance with the charter and by-laws of the Institute. In the absence of the President the chair shall be taken by the Senior Vice-President present at the meeting; in the absence of the President and all Vice-Presidents, the members present shall select the Chairman of the meeting.

Par. XIX.—The Vice-Presidents shall hold office for two years, but two of them shall retire annually.

Par. XX.—The Council shall hold office as provided below, and members of it shall be eligible for immediate re-election provided that, as to the President, no person shall be eligible for immediate re-election to this office who has served for the two preceding consecutive years. In case an officer whose term has not expired becomes a candidate for a higher office at the annual election and be elected, his election to such higher

office shall automatically create a vacancy in the office formerly held by such member. The members in session at the annual meeting shall then proceed to elect a successor in the office thus vacated, and in the event of their failure to do so, the Council shall make the appointment.

Par. XXI.—The Councillors of the Institute shall be sixteen in number, eight of whom shall be elected annually for a term of two years.

Par. XXII.—Should a vacancy in the Council arise from any cause during any year, the Council may select, by letter ballot of the whole Council, a member of the Institute to fill the unexpired term.

Par. XXIII.—The Treasurer shall receive all moneys payable to, or accruing to, the Institute, and deposit the same in a chartered bank to the credit of the Institute. He shall sign and issue all cheques for money to be paid, notes and drafts, endorse cheques and all other negotiable paper made payable to the order of the Canadian Mining Institute, and shall attend generally to the financial affairs of the Institute.

Par. XXIV.—The Treasurer, under the direction and management of the Council, shall pay accounts, shall keep, or cause to be kept, proper books of account, and shall enter all receipts and disbursements in a Cash Book. At the Council meeting next preceding the Annual Meeting of the Institute he shall present a duly audited statement of the receipts and disbursements of the financial year, and at such other times as the Council may direct he shall submit to it, for its consideration, a balance sheet showing the financial position of the Institute. If in the case of sickness, absence, or from any cause whatever, the Treasurer does not act for a period of one month, the Council may appoint a Treasurer pro tempore, who shall act with the powers of the Treasurer. The Council may remunerate the Treasurer at its discretion, but shall exact a guarantee company bond for such amount as they may deem necessary.

Par. XXV.—The Secretary shall keep a true and correct record of all the proceedings of the Institute, the Council and

all Committees, and also a correct list of the members and student members of the Institute with their addresses. He shall conduct the correspondence of the Institute and issue all notices of regular meetings, upon instructions of the Council as set forth in these by-laws, to the members of the Institute, the Council and all Committees. In the case of special meetings, under Paragraph XXXI. hereof, the President may issue the notice in lieu of the Secretary. The Secretary shall also have the custody of the seal of the Institute, and in case of refusal or inability to act, the Council may appoint a Secretary pro tem. The Council shall remunerate the Secretary at its discretion.

Par. XXVI.—The duties of all officers, unless otherwise specified herein, shall be such as usually pertain to the office or such as may be assigned to it by the Council or the Institute.

SEC. V.—ELECTIONS.

Par. XXVII.—The Council of the Institute shall appoint, not later than the 10th of October in each year, a Nominating Committee, consisting of one member representing each Province or Territory of the Dominion which has not less than ten members in good standing in the Institute, and the Provinces or Territories having less than ten members each shall all be represented by one member at large. Of this nominating Committee not more than three shall be members of the Council. This Committee shall submit to the Secretary a list of nominations of persons to all offices falling vacant at the end of the next Annual Meeting; copies of this list, (which it not a ballot), shall be sent by the Secretary to all members not less than sixty days prior to the Annual Meeting, and again with the ballot. Independent nominations signed by not less than five members of the Institute in good standing, may also be submitted to the Secretary not less than forty days prior to the Annual Meeting. The Secretary shall prepare a single ballot slip, containing all nominations made as above, and shall send it to all members not more than thirty-

five nor less than thirty days prior to the Annual Meeting. This ballot shall be the sole ballot used in the elections. The ballot shall be unsigned and shall be enclosed in an envelope marked "To be opened only by the Scrutineers," and this in an envelope addressed to the Secretary. This outer envelope shall bear the signature of the member voting, and ballots not thus endorsed on the outer envelope will not be counted. The candidates receiving the highest number of votes shall be elected. In case of a tie the scrutineers shall decide.

SEC. VI.—MEETINGS.

Par. XXVIII.—The Annual Meeting of the Institute shall be held on the first Wednesday of March in each year at such place as the Council may determine; the determination of the place of meeting to be made at least two months prior to the date of the Annual Meeting.

Par. XXIX.—Special Meetings of the Institute may be called for such time and place as the Council shall determine, and notice of such special meeting shall state the business to be transacted thereat, and no other business shall be considered at such special meeting. Upon a written requisition of twenty members of the Institute, specifying the nature and urgency of the business to be transacted, the Council shall be obliged to call a special meeting of the Institute not later than one month after the receipt of the requisition.

Par. XXX.—Meetings of the Council shall be held at the headquarters of the Institute in the City of Montreal, but when an Annual Meeting shall take place elsewhere than at headquarters, Council meetings may be held at the place of the Annual Meeting, during and for two days immediately before and after such Annual Meeting. Any notice calling an Annual Meeting shall be deemed to be sufficient notice of the meetings of Council specified in the above preceding sentence, whether such Annual Meeting be held at headquarters or elsewhere.

Par. XXXI.—Regular meetings of the Council shall be held at headquarters in the first week in October, December,

February and April of each year, at such specific time and place as the Council shall determine. Special meetings of the Council may be called at headquarters by the President, or upon a written requisition to the Secretary of at least five members of the Council, by giving at least two weeks' notice through the mails. In the event of it being advisable, in the opinion of the Council, to hold special Council meetings elsewhere than at headquarters, this may be done by a vote in person or by letter ballot of a majority of the whole Council. Two weeks' notice of such meeting must be given to all members of the Council.

Par. XXXII.—At all meetings of the Council five shall be a quorum for the transaction of business, and as soon as possible after each meeting copies of the Minutes shall be sent to each member of the Council. In the event of a majority of the whole Council signifying to the Secretary a wish to reconsider any act of a Council meeting, this shall be done at the next regular Council meeting, and letter ballots shall be accepted from such members as are unable to be present, and a majority of votes shall decide the point at issue.

Par. XXXIII.—In its discretion, the Council may appoint special committees, either from its own body or from the membership at large, for the purpose of transacting any particular business or of investigating any specific subject connected with the objects of the Institute, and shall request such committees to report either to the Council or to the Institute as it may see fit.

Par. XXXIV.—The Council shall make an annual report to the Institute on the year's business, and in this, shall embody the financial statement of the Treasurer

Par. XXXV.—All questions coming before any meeting of the Institute, Council or Committee, shall be decided by a majority of votes of the members present and voting, unless otherwise specified in the By-laws.

Par. XXXVI.—Notice of all meetings of the Institute, whether regular or special, and of all meetings of the Council, except meetings authorized by Paragraph XXX. hereof, shall

be sent by mail at least two weeks in advance. The business of special meetings shall be specifically stated. The business of regular meetings shall be stated, so far as is practicable.

SEC. VII.—LIBRARY.

Par. XXXVII.—The Library of the Institute shall be kept in the City of Montreal. The control and care of the Library shall be vested in the Council, which shall appoint a Committee of three members of the Institute, at least one member of which (chairman) shall be a member of the Council. The commitee shall be known as the Library Committee, and shall have supervision of the Library. The Council may also appoint a librarian, who shall have charge of the library, subject to the Library Committee. The Librarian may be remunerated for his services at the discretion of the Council, which may require a bond from him.

SEC. VIII.—PUBLICATION.

Par. XXXVIII.—The Council shall appoint an Editorial Commitee, of which the Chairman (at least) shall be a member of the Council. This Committee shall receive and consider each paper submitted to the Institute and shall advise the Council, which shall have power to publish or decline to publish any paper which may be communicated to the Institute at its meetings. All papers, and, so far as possible, all discussions shall be published first in pamphlet form "subject to revision," and distributed to all members as promptly as possible.

Par. XXXIX.—The Institute, as a body shall not be responsible for the statements and opinions advanced in the papers which may be read, or in the discussions which may take place at its meetings.

Par. XL.—The copyright of all papers, plans, maps and drawings accepted by the Institute shall be vested in it, unless other agreements are specially entered into between the Council and the author. The author of each paper accepted

and printed shall be entitled to fifty copies for his own use and additional copies at cost.

Par. XLI.—Premiums and prizes, at the discretion of the Council, may be given annually for papers read by the students during the year. Any such award shall be made by the Council within two months after the Annual Meeting.

Par. XLII.—Each member not in arrears shall be entitled to a bound copy of the Journal of the Institute for the year for which he has paid his subscription. Each student member not in arrears shall be entitled to an unbound copy of the said Journal.

SEC. IX.—AUDIT.

Par. XLIII.—An auditor or auditors, one of whom shall be a chartered accountant, not a member of the Institute, shall be appointed yearly at the Annual Meeting. The duty of the auditors shall be to audit and examine the books and accounts of the Institute, and to certify to the correctness of the annual balance sheet submitted to the Council, prior to the Annual Meeting. The auditors may be remunerated at the discretion of the Council, and they shall also act for the Council during the year when requested to do so.

SEC. X.—RESIGNATION.

Par. XLIV.—No resignation shall be recognized unless it is sent in writing to the Secretary, and also unless all amounts which may be due to the Institute by the resigning member shall have been paid.

SEC. XI.—BRANCHES.

Par. XLV.—The Council may, from time to time, make such arrangements as it may deem best for the establishment and maintenance of local branches or sections of the Institute in mining camps, towns or districts which may have a considerable number, not less than ten, of members resident in such camp, town or district. These branches shall be gov-

erned by such regulations as may be made by the Council. In its discretion, the Council may grant such financial aid to such branches as it may deem necessary or desirable.

SEC. XII.—NOTICES.

Par. XLVI.—Any notices required to be given to any member or student member, under these By-laws, shall be sufficiently given by being mailed, postage prepaid, in any post office in Canada directed to the address of such member as recorded in the Secretary's book.

SEC. XIII.—DISSOLUTION.

Par. XLVII.—The Institute shall not be broken up nor dissolved unless by the vote of two-thirds of the members present at a special general meeting convened for the purpose of considering such dissolution, and after confirmation by a similar vote at a subsequent meeting to be held not less than three nor more than six months after the first meeting, and notice of the last meeting shall be duly advertised as the Council or the Institute may determine.

SEC. XIV.—AMENDMENTS TO BY-LAWS.

Par. XLVIII.—These by-laws may be amended at any Annual Meeting by a two-thirds vote of the members present and voting, provided that written notice of the proposed amendment shall have been sent to each member at least one month prior to the date of meeting.

Par. XLIX.—The above By-laws shall come into force as soon as adopted by this Institute, except that the officers and Council elected at this Annual Meeting of 1905, shall remain in office until their successors are elected in accordance therewith.

EIGHTH SESSION—FRIDAY AFTERNOON.

The members re-assembled on Friday afternoon at three o'clock.

The President—I have here the report of the scrutineers on the election for the ensuing year, which I will read.

SCRUTINEERS' REPORT.

We the undersigned scrutineers, beg to report the result of the vote on the officers for the ensuing year as follows:—

President.....Geo. R. Smith.
Vice-Presidents—
Nova Scotia.....Thos. Cantley.
Ontario.....Dr. W. L. Goodwin.
Quebec.....Dr. F. D. Adams.
Secretary.....H. Mortimer-Lamb.
Treasurer.....J. Stevenson Brown.
Council—
Nova Scotia.....Chas. J. Coll.
C. A. Meissner.
W. B. Robb.
Ontario.....Dr. A. E. Barlow.
A. B. Wilmott.
Quebec.....J. Obalski.
R. T. Hopper.
H. J. Williams.
British Columbia.....R. R. Hedley.

(Signed)

A. W. STEVENSON,
A. P. LOW,
FREDERICK HOBART,
Scrutineers.

The President—I have much pleasure, gentlemen in declaring all these officers elected, and in congratulating them on their election. It is unnecesary for me, gentlemen, to introduce to you our new President, as Mr. Smith is so well known to you all.

Mr. Smith, the new President, in taking the chair, said: "Gentlemen, I do not propose to inflict a speech on you under the circumstances, but I think it would not be out of place in thanking you for the honor you have placed upon me, to make

a few remarks in connection with the Mining Institute. I have the greatest confidence in the gentlemen who have been elected to serve with me on this year's Council. My one ambition will be, as president, to carry out the good work that the Institute was organized for. I feel a little difficulty before me to-day in expressing exactly how I feel in connection with this honor you have conferred upon me. I only think you have accepted me because Quebec was entitled to its turn to have a President; but I will say that Quebec has had a great deal to do with the formation of the Mining Institute. In 1887 we had much mining business at Buckingham, and in the interests of mining here, and also of mining throughout the Dominion of Canada, we believed that if we resolved ourselves into a body we might have more weight with the Government, who, at that time was attempting to pass a law that would have been prejudicial to mining interests not only in the Province of Quebec but in the Dominion of Canada. We formed ourselves together, and that, gentlemen, was the nucleus of the Canadian Mining Institute. We were the Quebec branch, and with the help of Nova Scotia, Ontario and British Columbia, we have to-day what I believe every member should feel thoroughly proud of, an Institute whose strength is known from ocean to ocean through the Dominion of Canada. I think we can carry weight with any government, either at Ottawa or in the provincial arena. I am going to continue the good work of the Canadian Mining Institute with the help of the other officers that have been elected with me. I hope we can carry on the work that has been started. I hope that we can help strengthen this Institute; gather together men who are interested; and I ask you, the professional mining men of the country, to lend me your assistance in carrying on the good work of the Institute this year. I realize the honor that has been conferred upon me, and I wish to thank you most heartily. I need hardly add that I shall endeavor to further the best interests of the Institute."

It was then moved by Mr. H. Williams, and seconded by Mr. Hopper, that a vote of thanks be extended to the retir-

ing officers, the scrutineers and the committee appointed to deal with the revision of the by-laws.

The motion was carried with applause.

ELECTION OF AUDITORS.

On motion, the Council was authorized to select a chartered accountant as auditor for the incoming year.

The following papers were then read:—

Wrought Pipe; Threading and Relative Durability of Steel and Iron. By Mr. Frank N. Speller, of Pittsburg, Pa.

Los Reyes Gold Mines, Mexico. By Mr. Alex. Smith, Oaxaca, Mexico.

Mr. W. G. Miller gave a brief, extemporaneous account of the cobalt-silver deposits which have been discovered in the vicinity of Lake Temiskaming, Ont., during the last year. Mr. Miller has published a geological map and a paper descriptive of the deposits in the annual report of the Ontario Bureau of Mines which can be obtained free of charge from the office in Toronto.

The following papers were presented and read by title in the absence of their authors :—

Iron Pyrites in Eastern Ontario. By E. L. Fraleck, M.E., of Belleville, Ont.

Method of Time and Cost of Keeping of Copper Cliff Mine, Ont. By E. A. Collins, Kingston, Ont.

On the Occurrence of Hematite North of Little Current, Georgian Bay. By S. Dillon Mills, Toronto, Ont.

Indicator Cards. By W. D. L. Hardie, M.E., Lethbridge, Alta.

A Canadian Dellwik-Fleischer Water Gas Plant. By E. A. Sjostedt, Sault Ste. Marie, Ont.

Before the proceedings terminated, Dr. Porter asked permission to make a motion. He said: I am extremely grateful to the outgoing President for what he has done for the Institute, and I shall have great pleasure in moving a hearty vote of thanks to Mr. Coste for his zeal in attending to the work of

the Institute, and particularly the publishing and the securing of papers."

Dr. Goodwin—I have very much pleasure in seconding this resolution. One has only to look over this table to see what the results of the retiring President's work has been, in part as Acting Secretary and in part as President. Such a resolution is only due to him at this stage, and I have very much pleasure in seconding it.

The President—Before putting this motion, it will give me a great deal of pleasure to express my appreciation of our past President. I have known Mr. Coste for, I think, twenty-three years, in connection with the mining industries of this Dominion. I have known him as a faithful, conscientious worker, and I do not know of any higher praise than that over twenty years ago Mr. Coste's report on a mining property proved to be a valuable report. Since that time he has been making reports and doing mining work in Canada and is well and favorably known throughout the Dominion as a mining engineer of the highest standing. Mr. Coste as a past President will be a member of the Council and I realize that in having Mr. Coste for a past President, I shall have a valuable assistant in the Council, one that I know will help me and to whom I can go in times of difficulty. I can appreciate that there may be such times coming for me. I have very much pleasure in putting this motion. It is moved by Dr. Porter, seconded by Dr. Goodwin: That this Institute records its appreciation of the valuable services rendered to it by the retiring President, Mr. Eugene Coste, who has during the past year added to the occupations of a busy life the duties of Acting Secretary of the Institute. His work has resulted in the publication of a large edition of the current volume of the Journal, of a list of members up to date, and of advance copies of papers read at this meeting. The thanks of the Institute are also due to Mr. Coste for initiating the revision of the by-laws and for getting together a list of papers for this meeting which has made it one of the best meetings in the history of the Institute.

The President (continuing)—"I cannot add more, I think, than is expressed in that motion. It seems to me that it expresses almost everything. If I could add more to it, I should be happy to do it, Mr. Coste."

The motion carried unanimously.

Mr. Coste—Mr. President and gentlemen, I am very grateful indeed to receive this appreciation of such services as I have been able to render during my term of office. I could not have done less, being a mining man and loving my profession. I stand ready to do, perhaps not quite so much, but to do all possible to help our President, and my old friend, Mr. Smith. Mr. Smith's kindly reference appertains to a matter that occurred many years ago, and we have been very good friends ever since. I thank you again for your kind motion, and the way you have expressed it. (Applause.)

The meeting then adjourned.

On Friday evening, at eight o'clock, many of the members met in the Windsor Hotel, Montreal, to attend a smoking concert, which was thoroughly enjoyed by those present. During the evening, Mr. Congdon, ex-Governor of the Yukon, delivered an address on the conditions in the Yukon. His remarks were listened to with great interest, and fitly concluded a most successful meeting.

THE GOLDFIELD DISTRICT, NEVADA.

By E. P. Jennings, Salt Lake City, Utah.

The following notes are based on a month's examination of the district made in the summer of 1904.

Goldfield is located at the southern end of the San Antonio desert, 25 miles due south of Tonopah, in Esmaralda County, Nevada.

The first locations in this now famous gold camp were made in the summer of 1903, and the first rich ore was discovered on the Combination claim in the fall of the same year. This was followed by the opening of rich ore bodies in the January, Jumbo and Florence claims, and in September, 1904, the richest ore yet discovered was uncovered in the Sandstorm claim. New discoveries are reported almost daily, but many of them as yet lack confirmation.

While it is difficult to estimate accurately the value of the ore produced to date, it is reported that about $2,000,000 worth has been shipped to the Salt Lake City smelters, that averages from $200 to $300 per ton, with some exceptional car load lots running as high as $3,000 per ton. All ore mined of a value below $100 per ton remains on the mine dumps, awaiting the advent of suitable milling facilities for its reduction. The values are almost entirely gold—only traces of silver being found in much of the ore.

Physically the country is an absolute desert; the rainfall being confined to a few local showers in the summer, and some seasons these are lacking.

The level of the ground water is high for an arid country, and has been reached in some of the mine shafts at depths of 150 to 200 feet. Water is also obtained in shallow wells in the town of Goldfield and from springs having their source in the mesa south and west of the town. Its relative abundance suggests sources in the great snow covered range of California.

Topographically the district may be described as an amphitheatre about three miles in diameter, the floor of which is a series of low hills, the trend of their longer axes being north-south, surrounded by somewhat higher hills on the north, east and south and a lava-capped plateau to the west.

The crests of the hills are crowned by prominent "quartz reefs" that project above the surrounding country; their greater hardness enabling them to withstand the erosion that has removed the softer country rock. These reefs are irregular in outline, varying from fairly regular dike-like forms to the most irregular masses. They are not continuous for any distance, but disappear and reappear at short intervals and with great variations in their strike.

The entire region is covered with flows of eruptive rocks of Tertiary Age that rest on beds of sedimentary rock of unknown but probably Paleozoic Age. These sedimentary beds are exposed on the flanks of Columbia Mountain in the northern part of the district, and in a chain of lower hills extending easterly from this mountain. The hills have been formed and the altered limestone which is the only representative of the sedimentary beds, elevated to its present position by intrusions of alaskite, a quartz-feldspar granite. The limestone when exposed rests upon the alaskite, and has been greatly altered and silicified. It has been called jasperoid by J. E. Spurr, of the U. S. Geological Survey. This jasperoid is a dark grey to black rock, fine grained and breaking with a splintery fracture. After the intrusion of the alaskite the entire country was covered with flows of rhyolite of three and possibly four different periods, with long time intervals between them. The lower sheets are greatly altered and more or less silicified by the subsequent introduction of silica, and contain no ferro-magnesian minerals. The remnants of the later flows on the flanks and summits of the hills bordering the district are more basic, containing scanty biotite and hornblende.

The country rock of the mineral veins is the lower rhyolite, and contains all the minerals so far found, the later flows having been eroded. We may infer that this sheet of unknown, but limited, thickness rests on the limestone before described.

The composition of the rhyolite is similar to the alaskite, and while proof is lacking, it is not improbable that both are due to the same magma; the rhyolite, however, being a surface flow of later date than the alaskite.

The entire district is characterized by the acid type of the eruptives and the universal distribution of gold in the older rhyolites.

The quartz reefs are altered rhyolite, which has been more or less completely converted into a jasper-like quartz, with no indications of a vein structure, and no well defined boundaries, but gradually fading into the rhyolite. That they extend to no great depth is shown in a number of instances where shafts have been sunk through these quartz masses and passed into softened rhyolite below.

These reefs carry from traces to a few dollars in gold, very irregularly distributed; also small amounts of barren pyrite.

The rich ore occurs in irregular seams, small breccia-zones, and lenticular shaped cavities in the jasper reefs. Explorations have so far shown that they have no regularity or continuity, changing in strike and dip or disappearing entirely. The values also change abruptly from rich shipping ore to barren material. The breccia-zones so far have been the most regular, as might be expected, and the talc seams, the most irregular, often extending but a few feet horizontally and vertically, but forming very rich pockets. The ore in the breccia-zones is composed of roughly rounded masses of gray jasper, evidently portions broken from the quartz reefs, corroded and bleached to a depth of a quarter to half an inch and loosely cemented by talc, clay and material resulting from the decomposition of the country rock. The values are mostly continued in this cementing material. In some instances the talc and clay have nearly replaced the breccia, giving the deposit a vein-like character.. Many of the reefs have been fractured and the fissures filled with brecciated material derived from the walls and firmly cemented with silica. Breccia-zones of this character are low grade or barren, and differ greatly in this respect from the breccia-zones before described, in which the cementing material is clay or talc, and suggest a different period

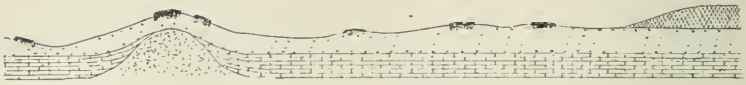


FIG. 1. N-S GEOLOGICAL SECTION GOLDFIELD, NEV.

PLASMITE LIMESTONE RHYOLITE INTERERUPTIVES QUARTZ REEFS

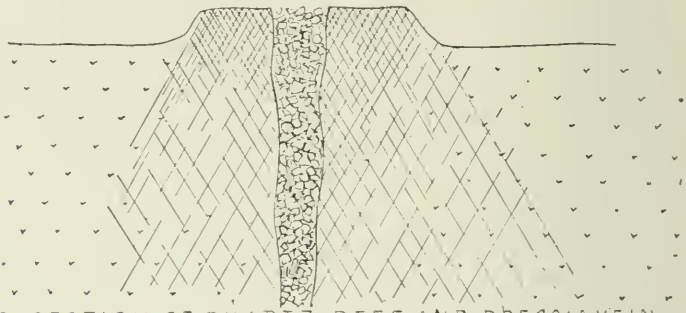
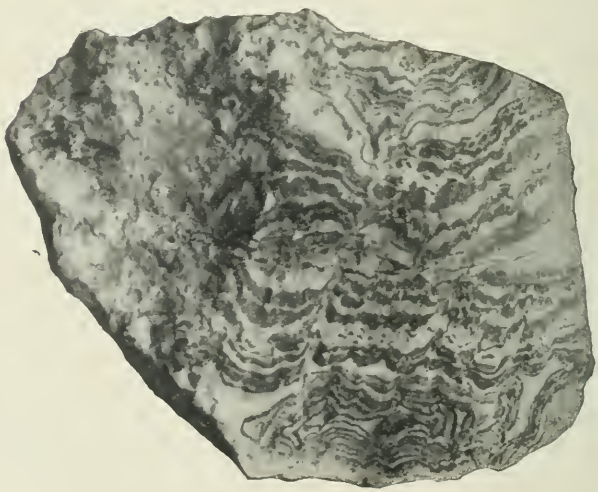


FIG. 2. SECTION OF QUARTZ-REEF AND BRECCIA-VEIN.

RHYOLITE QUARTZ-REEF BRECCIA-VEIN.



of formation when the solutions were richer in silica but poorer in gold.

The ore so far shipped has been entirely oxydized, but sulphites have been noted in the Combination and January mines below water level, consisting mostly of pyrite and very small amounts of a gray, copper-bearing mineral. These sulphites are reported as containing high values, but as they occur near the water level where the gold would readily be precipitated on the sulphides, the high values may be considered as due to the zone of enrichment. Bismuth is also reported as a sulphide in the Combination and as an oxide in the January. A yellow mineral giving reactions for iron and sulphuric acid, occurs as a coating on the ores of the breccia veins; it is probably a basic ferric sulphate due to the oxydation of pyrite, and is considered an indication of rich ore.

The writer infers that the formation of the quartz reefs and the subsequent deposition of the ore can best be explained by the action of descending waters acting under the well known laws of metamorphism, and will consider the genesis of the ore bodies from this point of view, referring the reader to Van Hise's exhaustive treatise* for further information on the subject of metamorphism.

The original quartz reefs consisting of more or less altered and silicified rhyolite, can be considered due to the action of descending waters which have derived their silica contents from a former belt of weathering,† represented by the later flows of eruptives and tuffs, but now eroded, and the deposition of this silica along irregular fractures in the belt of cementation,‡ and replacing the rhyolite more or less completely by silica for some distance from the original fractures. This replacement often retains the original flow structure of the rhyolite, as shown in Fig. 3, which is a piece of surface rock from the Sandstorm claim, where rock of this character is abundant. As before stated,

* Van Hise, C. R., A Treatise on Metamorphism, Mon. U. S. Geol. Survey, vol. 47, 1904.

† Van Hise, op. cit., p. 409.

‡ Van Hise, op. cit., p. 562

these silicified zones have no well defined limits, but fade into the country rock.

The original source of the gold is undoubtedly the eruptive rocks as they contain from traces to $2.00 per ton. This has been leached from the belt of weathering by descending water containing the well known solvents, ferric sulphate and ferric chloride, and, to a less degree, the corresponding cupric salts, which has redeposited its gold content in seams, fissures and breccia-zones in a lower belt; ferrous salts and sulphides as pyrites acting as the precipitating agents. The original rocks contained all the elements required to form solvents in the belt of weathering and the precipitants in the lower belt.

The operation of solution and precipitation has been repeated as the surface rocks weathered, and were removed by erosion until we have as results of this phase of secondary enrichment, small veins of very rich ore that may be called the roots of veins which formerly extended many hundred feet above their present position, and contain practically all the values contained in the horizon now eroded. Undoubtedly this chemical process has been supplemented by mechanical concentration due to the removal of the lighter disintegrated material, through the agency of wind and in a less degree, water, leaving the heavier gold in the upper part of the vein.

Whatever view may be taken as to the primary mineralization of the veins as new data is offered by deeper exploration, it is safe to assume that the rich ore is due entirely to secondary enrichment. This is possible in any arid climate where the rainfall is small but sufficient to furnish water for the chemical reactions required to dissolve the gold, but insufficient to lessen their solvent action by dilution, or wash the solutions into the surrounding soils and water courses.

The geological sequence is as follows:

The intrusion of the alaskite into the sedimentary beds; the flows of rhyolite; the transference of silica and small amounts of gold from the belt of weathering to a lower belt and the formation of the low grade quartz reefs; the fracturing of some of these reefs and concentration of gold by the chemical action of

descending water, supplemented by mechanical concentration; these operations being constantly repeated as erosion progressed.

This method of ore formation is true of a number of deposits of silver-lead in the same region, and, in general, to many occurrences of ore in the arid portion of western America.

Deposits of this character are not to be confounded with the deep-seated fissure veins of the Tonopah class, that have derived their mineral content from ascending water, and been subsequently enriched by descending solutions.

It is probable that many more rich seams will be found at Goldfield and the surrounding country where the geological conditions are similar; in fact several camps have been located recently on the desert south of Goldfield, but their value is yet undetermined.

Goldfield is a center of great activity at the present time; new companies are being formed almost daily, and their stocks offered to the public. Undoubtedly in some instances the propositions have merit, but in others their only assets are certain areas of barren desert.

WROUGHT PIPE—THREADING AND RELATIVE DURABILITY OF STEEL AND IRON.

By Frank N. Speller, Pittsburgh, Pa.

Soon after soft steel began to supersede wrought iron in general engineering construction on account of its superior strength, ductility, toughness and uniformity in composition, the question of relative durability was brought up. This led to many elaborate experiments under conditions approximating those which promote corrosion in practice which have been continued and discussed by many of the best investigators for the past twenty-five years.* The most trustworthy of these results up to 1892 have been concisely reviewed and compared by Prof. H. M. Howe,† with the conclusion that, so far as the relative corrosion is concerned, no important difference exists between iron and steel although the variable effect of different conditions is more marked. Later, in 1895, the same investigator expresses his conclusions in a paper entitled "Relative Corrosion of Wrought Iron and Steel," in the following terms: "It is misleading to say that normal low carbon steel corrodes more, or that it corrodes less than wrought iron, since the relative corrosion varies with the enclosing medium. I think that we have every strong reason to believe that such steel, when carefully made, resists corrosion in fresh water as well as wrought iron; in cold sea water, at least nearly as well as wrought iron; and in acidulated water better than wrought iron."

At the meeting of the International Society for Testing Materials, in 1900, Prof. Howe gave further data from some

* T. Andrews—Inst. C.E., Vol. LXXVII, p. 323; Vol. LXXXII, p. 281. Inst. C.E., Vol. LXV, p. 101; Inst. Journ., 1881, Vol. I, p. 39, W. Parker (Lloyd's Register).

† Metallurgy of Steel, p. 94.

large scale experiments conducted by himself, in which he exposed a number of plates of wrought iron, soft steel, and nickel steel, one-eighth inch thick, to the action of sea water, river water, and the weather, for two periods of one year each. The results are summed up as follows:

RELATIVE LOSSES.

	Sea Water.	Fresh Water.	Weather.	Average.
Wrought iron	100	100	100	100
Soft steel	114	94	103	103
3% Nickel steel	83	80	67	77
25% Nickel steel	32	32	30	31

Prof. R. H. Thurston,‡ from his tests and observation of these materials in practice, concludes on the whole that steel resists corrosion better than iron.

The most dangerous form of corrosion in pipes is pitting. Some tests made by the United States navy department* during the past three years give some interesting data on this point, and suggested other investigation along this line to the writer, results of which will be given later. The Navy Department tests were made in aerated distilled water at normal temperature of room on 48 pieces of each of the following materials: charcoal iron, Bessemer steel, and hot and cold drawn seamless tubes made from same lot of open-hearth steel.

The samples were of steel from all parts of the ingot, and were insulated in 12 porcelain lined tanks, a plentiful supply of pure air being supplied through perforated glass tubes. At the end of each period of 16 weeks the samples were removed, cleaned and weighed. While under test, every precaution was taken to subject each piece to the same corrosive influences as the others. It will be seen that the essential conditions of corrosion, viz., oxygen, carbonic acid and moisture, were here given free play; the following are average results compiled from the experimental data:

‡ "Materials of Engineering." Iron and Steel.

* Jour. Amer. Soc. of Naval Engineers, May, 1904.

TABLE 1.

Average Loss in Grammes Per Square Inch.

	After 16 Wks. (1st 16 Wks.)	After 32 Wks. (2nd 16 Wks.)	After 48 Wks. (3rd 16 Wks.)	After 64 Wks. (4th 16 Wks.)	Total Average Loss 64 Wks.	Comparing with Iron as 100.
1. Hot drawn seamless O. H. steel	.3034	.5333	.3510	.5070	1.6947	93.7
2. Lap-welded Bessemer steel	.3147	.4950	.4043	.4945	1.7085	94.5
3. Cold drawn seamless O. H. steel	.3232	.5564	.4502	.5017	1.8315	101.3
4. Charcoal iron	.3326	.5896	.3966	.4893	1.8081	100.

Average Analyses of Material Under Test.

	Cold Drawn Seamless.	Hot Drawn Seamless.	Bessemer Steel.	Iron.
Silicon	.005	.005	.008	.024
Sulphur	.043	.039	.081	.014
Phosphorous	.015	.016	.110	.038
Manganese	.50	.49	.31	Trace.
Carbon	.16	.14	.063	"
Oxide and slag	....	....	....	1.03

The individual losses show an equally wide variation for all classes of materials. All pieces were carefully photographed after the first and fourth period of 16 weeks. Those showing the greatest and least loss in weight are reproduced herewith for Bessemer steel and charcoal iron.

Table 1A shows losses sustained by samples of Bessemer steel and charcoal iron tubes cut so as to include or avoid the weld.

TABLE 1A.

Three-inch Boiler Tubes, No. 9, 13, W. G.
Lap Weld Iron.

Average loss in grams per square inch of samples with and without weld.

With Weld:

First Period.	Second Period.	Third Period.	Fourth Period.	Total.
.3378	.6109	.4155	.4978	1.862

Without Weld:

.3274	.5684	.3777	.4808	1.7543

Three-inch Lap Weld Bessemer Steel Tubes.
Average losses in grams per sq. in.

With Weld:

First Period.	Second Period.	Third Period.	Fourth Period.	Total.
.3089	.4854	.4120	.4952	1.7015

Without Weld:

.3050	.5022	.4004	.4981	1.7057

The least and greatest average loss, it will be noted, was sustained by open-hearth steel, while iron and Bessemer steel

show no important difference, but lie between the maximum and minimum. This goes to show that any slight difference in corrosion, due to essential differences in composition of these materials is insignificant compared with other considerations.

The photographs show that the pitting is relatively equal, as near as can be seen, in each class of material, except in the case of the cold drawn seamless tubes which had a very thin scale and were but slightly pitted. This disproves the claim of some manufacturers of wrought iron that it does not pit.

Mill scale, being electro-negative to iron (about 4.10 volts) is evidently largely responsible for the deep corrosion on bare metal adjacent to firmly attached scale.† Further, it has been found that duplicate plates of iron and steel exposed with and without mill scale on their surfaces, sustain nearly the same loss in weight, the clean surface being uniformly corroded, while the scale bearing surface is more or less pitted. This explanation of the cause of pitting, which seems to satisfactorily account for the facts observed, applies equally to all classes of iron and steel.

TABLE 2.

Loss in Milligrams per Square Inch, Exposed 500 Hours in Aerated Water at 175° F. Pieces in Electrical Contact and Insulated * as Indicated.

Nature of Solution.	Charcoal Iron (C.I.)	*With.	Common Iron (Z.).	With.	Bessemer Steel.	With.	O.H.Steel.	With.
Distilled Water	188	*	180	.....	174	.....	185	.....
" "	154	Bess.	130	O.H.	150	C.I.	165	Bess.
" "	140	Z.	100	C.I.	173	O. H.	122	Z.
Alkaline Boiler Water.....	192	*	223	.....	240	.....	224	.....
Alkaline Boiler Water.....	230	Bess.	175	O.H.	210	C.I.	230	Bess.
Alkaline Boiler Water.....	190	Z.	177	S.E.	163	O. H.	200	Z.
Ferrous Sulphate in hot water *without air*, 15 grs. per gal.	51	*	50	.....	56	.....	41	.....
	57	Bess.	53	O.H.	25	C.I.	28	Bess.
	54	Z.	75	C.I.	66	O. H.	46	Z.
Strong Sodium.....	335	*	292	.....	186	.....	210	.....
Sulphate Solution, slightly Alkaline ..	504	Mill Scale	394	Mill Scale	454	Mill Scale	420	Mill Scale
Boiler Water (150 lbs. pressure) carrying ferrous sulphate, 50 grs. per gal.....	2022	Z.	1765	C.I.	1985	C.I.	1442	Z.
	1987	Bess.	1565	O. H.	1970	O. H.	1495	Bess.

†Journ. Iron and Steel Inst., 1879, Sir N. Barnaby, p. 53; 1887, Vol. I, p. 461.

ANALYSIS OF ABOVE MATERIAL.

Sulphur	.015	.030	.061	.030
Phosphorous	.020	.140	.098	.005
Manganese	Trace	Trace	.31	.42
Carbon	Trace	Trace	.07	.11
Oxide and slag	.80	1.70	....	....

The effect of contact of dissimilar irons and steels with each other and with plates of the same material carrying the natural mill scale, was the subject of experiments made at the laboratory of the National Tube Company, McKeesport, Pa., last year. The results, averaged and condensed, are given in Table 2. In these experiments, test pieces were prepared by removing all mill scale.

In these tests, made in hot aerated solutions, the common iron and Bessemer steel appear to be almost equal, while both resist corrosion somewhat better than the higher grade charcoal iron, but the difference cannot be said to be important.

The corrosion of those pieces electrically connected did not increase, as a rule, as might have been expected—this may be explained by the coating (largely consisting of ferrous oxide) produced on adjacent sides of connected plates which seemed to successfully resist further oxidation. Galvanometer tests showed a variable and rapidly decreasing E.M.F., which often reversed its polarity at intervals of an hour or so. The E.M.F. between these materials was quite variable, but was usually less than one-fifth the potential between magnetic scale or rust, and iron or steel.

Experiments on a small scale are limited to certain fixed conditions which approximate to those in practice. Observations of corrosion of pipe in practice must in the first place, to make the results worth anything, be made on material in use under the same influences, to ensure which both materials should be in use at the same time. In making observations in the field, it is often difficult to determine just what conditions prevail and whether both materials were subjected to the same environment, for the conditions which most influence the rate of corrosion, besides oxygen and carbonic acid with moisture, which may be considered as primary causes, are intricately involved and subject to local change. For example:—1. Galvanic action, by (a) metallic

PLATE I

PLATE I

SAME SAMPLES AFTER SIXTEEN MORE WEEKS

LEAST

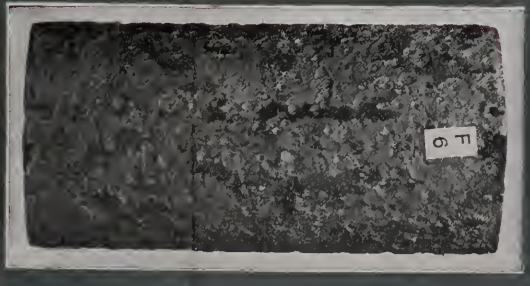
GREATEST

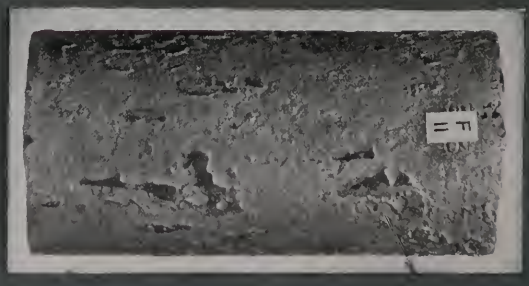
PLATE 3

CHARCOAL IRON LAP-WELDED TUBES, SHOWING CORROSION AFTER SIXTEEN WEEKS' EXPOSURE

LEAST

GREATEST





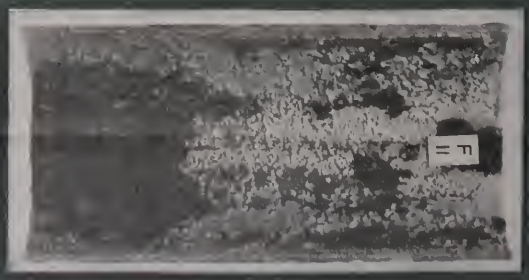


PLATE 4

contact†, (b) heating of one portion of the metal (thermo electric action), (c) straining one portion of a piece renders that part electro-positive to the unstrained metal. The difference in potential thereby produced is said to be sufficient to considerably effect the rate of corrosion of strained parts.‡

2. Electrolysis§ is a widespread and increasing accelerator of corrosion which all precautions cannot entirely prevent. A difference of potential of 1-1000 volt is sufficient to increase corrosion considerably and this may exist one or two miles from a dynamo.

3. Increased amounts of corrosive matter in air and water, especially near the large centres of population, where the greater portion of pipe is in use, together with the complicated and far-reaching action of stray currents, have materially increased the danger of corrosion during the past ten or fifteen years, since steel pipe began to be generally adopted, hence a fair comparison with pipe in use at a previous date is clearly impossible—yet many declaim and deplore the degeneration of present day pipe material. Fortunately much energy is being better spent in providing efficient protection for iron and steel exposed to such corrosive conditions. After all, probably the best evidence of the practical insignificance of the difference between the rate of corrosion of these materials, is the fact that after twenty-five years of investigation and discussion the question is not absolutely settled, there being still just enough difference one way or the other to indicate that under some conditions each material has a small advantage over the other, while in the majority of cases the differences are hardly perceptible.

The search for a boiler tube which will resist the action of hot acid solutions is gradually being abandoned—platinum being too expensive. A much more economical solution of the problem is to adopt some efficient and simple system of water purification.

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† Trans. R.S.E., Vol. XXXII, p. 218.

‡ Bulletin of University of Wis. No. 2, Engineering Series, Vol. II, No. 8, July, 1900.

§ "Rustless Coatings" (Wood), p. 370, Wiley & Sons, N.Y., 1904.

PIPE THREADING

In certain districts much has been heard from plumbers and steam-fitters on the difficulty of threading steel pipe, particularly in the field where hand tools must be used.

When soft Bessemer steel was first made by the National Tube Company for the manufacture of welded pipe, the question of tools was thoroughly investigated by the threading departments. Fig. 1 shows the old form of chaser which will cut a fair thread on iron as the metal is weak enough and so broken up in structure by interspersed cinder as to be more or less easily worked with such a tool. Bessemer steel of the quality proven to be best adapted for pipe, being much tougher and stronger than wrought iron cannot be pulled up by the roots in this manner, but a clean and easily cut thread may be made by putting an angle of shear on the chaser, as illustrated in various forms, Fig. 2.

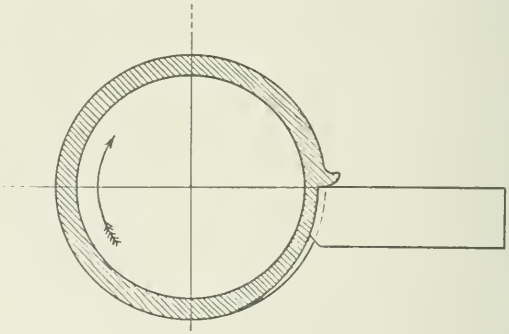


FIG. 1

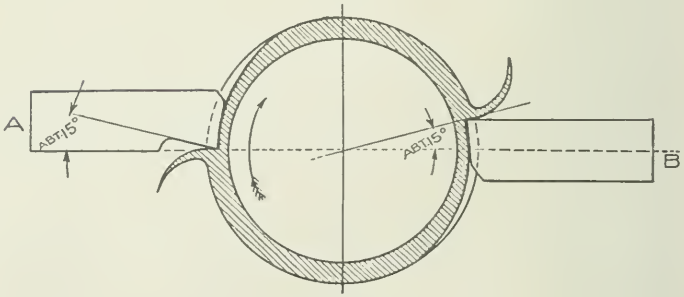


FIG. 2.

Care as to clearance and lubrication will also greatly facilitate the work. Good lard or cotton seed oil should be used in liberal quantities.

In machine threading, at the National Tube Works a proper form of chaser has proven to be the first consideration in economical thread cutting. Tools so constructed will cut steel or iron with equal ease, but mill records show better results with the tools used on steel, owing to the increased wear and tear caused by the 2 to 3% of cinder included in wrought iron. A recent investigation of hand-threading tools clearly showed that few are made on this principle, hence the trouble complained of by those using such tools on steel pipe was not hard to explain. After some experimenting in co-operation with several steam-fitters who had experienced this difficulty, it was found on changing the angle of shear that there was no perceptible difference in threading either iron or steel, and the result invariably gave a much stronger and cleaner cut thread on the steel pipe.

Many cases of split joints which necessitated the costly removal of lines have been traced to excessive torsion strains produced by use of poor threading tools. The damage is usually charged to poor welds, but every piece must pass the tester† before leaving the works, and, moreover, experience shows that the trouble ceases on altering the die or buying one of proper shape.

Bursting tests on three classes of wrought iron and steel pipe, made by Prof. Howe,* in 1897, gave the following results:

	2″ Line Pipe.	2″ Tubing.	5⅝″ Casing.
Wrought Iron, Minimum....	1,000	3,300	250
Steel, Minimum	2,300	5,150	1,450
Wrought Iron, Maximum ...	4,000	5,000	1,400
Steel, Maximum	6,000 (a)	6,000 (a)	2,750
Wrought Iron, Average	2,918	4,106	931
Steel, Average	4,733	5,800	2,038

(NOTE—Results in pounds per square inch. (a) This was the limit of pressure available.)

†Pipe made at National Tube Works is all tested from 600 to 2,000 lbs. per square inch according to the purpose for which it is made.

*Abstract in Engineering Record, October 1, 1903.

A comparison of the average results shows that the steel pipes excelled the wrought iron pipes by 62% in the line pipe, 41% in the tubing, and 119% casing. Prof. Howe's report concludes, "To sum up, the steel pipes excel the wrought iron very greatly in bursting strength, very considerably in tensile strength, and somewhat in offering less frictional resistance to the flow of water."

Further bursting tests recently made on Standard Butt Welded Pipe at the National Tube Works, McKeesport, Pa., gave the following results:—

Size.	Steel.	Iron.
½ in.	6500 lbs. per sq. in. (Did not burst).	6500 lbs. per sq. in. (Did not burst).
⅜ "	6500 " " "	6500 " " "
¾ "	6500 " " "	6500 " " Slight leak.
1 "	6500 " " "	6500 " " "
1¼ "	6500 " " "	5000 " " Burst.
1½ "	6500 " " "	4400 " " "

The average of a number of transverse tensile strength tests made on rings cut from separate pieces of Butt Welded Wrought Iron and Steel Pipe, gave the following:—

	Pulled in Metal.	Pulled at Weld.
Iron.....	34520 lbs. per sq. in.	24540 lbs. per sq. in.
Steel.....	61850 " "	46080 " "

This is a good index of the superior strength of a soft steel welded joint over one made with wrought iron, the soft steel *butt weld* being actually 33% stronger than wrought iron pulled in the same way, but *not including* the weld. The welded steel pipe evidently has a seam nearly twice as strong as that made of wrought iron.

Mild steel has had to live down prejudice in nearly every line where it has displaced wrought iron. The most suitable quality of Bessemer steel for pipe manufacture has been the result of much expensive experimenting and has proven much more satisfactory in welding. The process of manufacture of soft steel pipe being a continuous one from ore, through blast furnaces, Bessemer converters, blooming mill, rolling mills and tube works, under one management, with critical inspection at each point, insures the highest practical degree of uniformity in product. Steel scrap from the pipe and rolling mills, not used

up by the Bessemer department, finds a ready market at neighboring open-hearth plants. It is not an uncommon practice for some concerns making "strictly wrought iron pipe" to use a considerable portion of miscellaneous steel scrap of various composition. This often results in hard spots and weak welds, which, when discovered, are frequently credited to intermixed steel pipe. The prejudice created is so strong in some minds that any defective pieces are at once put down to the accidental shipment of some steel pipe with the order. A few such cases were investigated recently by the writer, where it was found that some fifty pieces of defective pipe (mostly open welds) were all "wrought iron" much to the surprise of the consumers. The National Tube Company, who furnished facilities for this paper, and many of the tests referred to, besides being the pioneers in the introduction of soft Bessemer steel pipe, manufacture wrought iron. In most lines, however, the older material has been displaced to advantage by modern pipe steel.

Naturally, the makers of wrought iron pipe, to whom a supply of suitable steel is not available, make the most of the suspicion which the word "steel" still raises in the minds of some people not informed on the modern advances in this industry. It seems quite reasonable to suppose that the advantages of superior strength, ductility, homogeneity, finish, and lower cost which accompanies the use of steel pipe would be more generally recognized if such misapprehensions as these regarding threading and corrosion were cleared up.

THE ADVANTAGES OF COMBINING TOPOGRAPHICAL WITH GEOLOGICAL SURVEYING IN UNEXPLORED REGIONS.

(ABSTRACT.)

By Dr. Robert Bell.

I wish to say a few words in defence of the system which has been pursued by the Geological Survey of Canada for upwards of sixty years in obtaining the necessary data for the construction of geological maps of previously unexplored regions. We cannot properly compare what may be done in other countries with the methods best suited for the wilder parts of Canada. Those who talk about the necessity for making topographical surveys independent of the geological work and in advance of it, do so in ignorance of the requirements of the case. In respect to this matter Canada stands alone; our country is so extensive and the number of geologists who may be employed is so small that we must necessarily do the best we can with the means at our command. We cannot follow any fixed rule which may suit some other part of the world, and even in regard to our own territory, we require to follow different methods in different parts of this vast country.

The cost of making anything like a complete topographical survey of Canada would be immense, and the time required would be too long for the geologists to wait, even if they followed in the footsteps of the topographers as rapidly as their work proceeded. The people of Canada want a preliminary knowledge of the geology of this country as soon as possible, and this may be obtained only by the system we have all along pursued.

The surveys required in order to divide up the lands of the Crown for the purpose of sale or settlement consist of straight

lines. These are run only in the areas best suited for agriculture and, hence, they are in regions where the rocks are of minor interest or importance, and where they are seldom exposed. On the other hand, the areas which are of least value for agriculture are often the most interesting geologically, and might not be topographically surveyed for a long time, unless this work was done by the Geological Survey Department. The straight lines which have been run for subdividing the agricultural lands cut but little figure in regard to the topography, and, therefore, it has come to pass that the greater part of the geography of Canada, with the exception of the main outer coast-lines, has been done by this Department. The shores of Hudson Strait and Bay and of James Bay have been surveyed by the Geological Department.

It may be said that, without attempting a general topographical survey of the whole Dominion as a preliminary to the geological mapping, the topography of certain districts may be done from year to year immediately in advance of their survey geologically. This could only be done with sufficient rapidity by following the same methods as those which are now pursued by the geologist, such as the surveys of rivers and lakes by the micrometer and the compass or transit, and of lakes by a system of rapid triangulation. Now, in doing work of this class, it would be difficult to find surveyors who could, without special training, get over the ground as quickly, or at so small a cost, as the official field geologists. The attempt to do the work separately would at least double the present cost in both time and money. By the system now followed, the topographical geologist is obliged to stop at every bend of a river and, of course, at every portage, and here rocks *in situ* are almost sure to occur. Similarly on the lakes, he is obliged to land on all the prominent points and islands. In doing this he cannot help seeing the rocks, and it requires little or no additional time to note what these may be. He can write his notes while his men are paddling his canoe from station to station. The additional time consumed in making special landings to examine the rocks is very slight. Again he

can take his observations for latitude at noon while the mid-day meal for himself and the men is being cooked, and he may also observe for latitude by the pole star while in camp for the night.

It will, therefore, be readily seen that a great advantage is gained both as to time and expense in pursuing the method which has been found to be the best after more than half a century's experience, by the large number of official geologists who have practised our methods, which are still in force.

CRUDE PETROLEUM AND ITS APPLICATION AS FUEL FOR INDUSTRIAL OPERATIONS IN THE HAWAIIAN ISLANDS.

By J. N. S. Williams.

The crude petroleum is obtained from oil wells in California, and is transported in sailing vessels, or steamships, having cargo tanks especially arranged for the purpose.

On arrival at destination, the oil is pumped from the vessels to large storage tanks on the shore, by means of powerful pumps carried on board the vessels for the purpose.

The crude oil is used as a fuel to replace coal, which is very expensive, ranging from $6.50 to $10.00 per ton, depending in the market and point of supply.

One hundred and sixty-eight gallons of California crude oil is taken to be equal in calorific value when burnt in the usual type of furnace under ordinary boilers, to 2,240 lbs. of average coal costing as above.

The cost of California oil delivered to the furnaces will average 3½ cents per gallon.

The specific purpose for which crude oil is used is for fuel in the furnaces of boilers furnishing steam to factories and pumping stations for irrigation, locomotives and steam ploughing engines.

The average quality of the coal used, as shown by various tests, is such, that burnt in ordinary furnaces attached to the ordinary fire tube, or water tube boilers, and with average skill in firing, one pound of coal will evaporate to steam at ninety pounds pressure 7.75 lbs. of water.

The average quality of the crude oil used, is such, that burnt in the burners to be described, from 12 to 14 lbs. of water are evaporated to steam at ninety pounds pressure per pound of oil; and as a rough general statement it can be said

that 6 lbs. of average crude oil are equal in heating power, under average conditions, to 10 lbs. of average coal.

In changing from coal to oil as fuel (as it had been well proven in other countries as a successful steam producer), the main consideration was the storage of the oil at the various establishments with a view to the safety of the surrounding property in case of the oil taking fire.

STORAGE TANKS.

The principal storage tanks are situated adjacent to the point of delivery from the vessels conveying the oil from California, from thence the oil is conveyed to the places where it is used. in railroad tank cars, holding about one hundred barrels each.

At every factory or pumping station a storage tank, containing from five hundred to two thousand barrels of oil, is erected and the oil from the tank cars is pumped into these tanks. Every battery of boilers is furnished with a service tank holding about twenty-four hours' supply, situated about fifteen feet above level of the grate bars, and the oil gravitates to the burners, or to the small pumps supplying the burners

The crude oil, as received from the vessels, is of a specific gravity at sixty degrees Fahr., varying from .942 to .957; its flash point, determined by the ordinary open cup method, varies from 115 degrees Fahr. to 237 degrees Fahr.

It gives off gas at ordinary temperatures, and this gas, so far as has been ascertained, consists of a mixture of Marsh gas CH_4, Olefiant gas C_2H_4, and Ethane (Ethyl Hydride) C_2H_6, and, doubtless, many other gases of this series are present in greater or lesser quantities. All of these gases when mixed with the proper proportion of air form explosive compounds, the maximum ruptive force of which varies from thirty to fifty pounds per square inch at the moment of explosion.

It will be seen, therefore, that crude oil is not a safe commodity to store in bulk, especially as sparks from passing locomotives, the flame of a lamp (if such is used for inspec-

tion), or lightning, will explode a tank, if the gas over the surface of the oil happens to be mixed with the proper proportion of air (about nine parts air to one part gas) to produce an explosive mixture. The tanks must be roofed to prevent undue evaporation, as oil of this nature will lose nearly one per cent. of its volume per day for two or three days after being filled into a storage tank, if the wind sweeps over it carrying away the gases as they are given off.

A roofed tank, however, shows very little evaporation in comparison, and is also a protection against sparks from passing locomotives, local fires, or other causes.

To facilitate the removal of accumulation of gases a small ventilator is placed in the roof of the tank, and the exhaust steam from the pump used for filling the service tanks, is turned into the space over the oil; this is very effectual in diluting past the danger point, and blowing away through the ventilator the gas accumulations from these storage tanks.

As a matter of fact, no accident has occurred where these precautions have been adopted.

BURNERS.

The burners used are of numerous different makes and styles, but all are based on the principle of atomizing the oil by steam.

One of the most successful burners in use is shown on Figure 1; this is made up of ordinary gas pipe and is not expensive; this is introduced underneath an ordinary fire door and the flame is projected forward over ordinary grate bars, which are protected by a layer of fire brick laid loosely on them, the air for combustion rising up through the spaces between the bricks, being thus distributed over the whole surface of the furnace. Combustion is smokeless when perfect, and the firemen can always tell when his burners are working properly by looking at the chimney gases as they escape.

The quantity of oil that can be properly atomized by such a burner is proportional to the amount of steam that can get through the steam opening in a given time; careful tests have

shown that steam required for atomizing fuel oil varies from one to four per cent. of that produced by the combustion of the oil.

The smaller the burner the more steam is used for atomizing in proportion to the quantity of oil atomized.

If the opening at the mouth of the oil burner is small, the cross section of the jet of flame will be small, the flame itself is lengthened, and it will impinge upon brickwork targets, or bridge walls with destructive effect; but with large oil openings the flame is much more diffused and furnace linings will last as long as or longer than they do with coal.

PUMPING STATIONS.

The following figures are the results of one year's work in five pumping stations, under the writer's care, using California oil as fuel.

Gallons of water delivered during year	7,673,000,000	
Average total lift	168 feet.	
Total oil consumed	1,421,221	gallons.
Average gallons of water pumped per hour	389,690	"
Crude oil consumed per hour	72.2	"
Weight of oil	563.16	pounds
Average water horse power	275.47	
Oil per water h. p. per hour	2.04	"

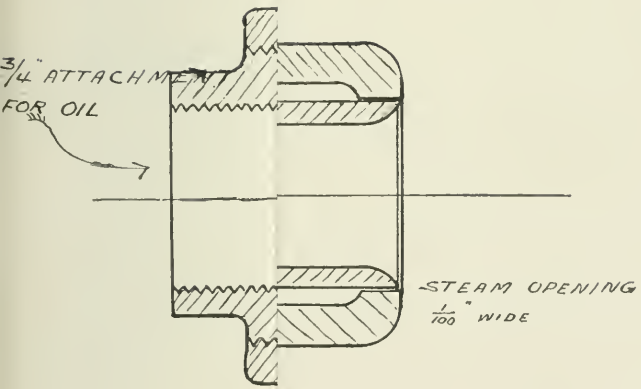
The pumping stations are fitted with engines of various sizes and styles: compound condensing slide valves engines; ditto, Corliss valve engines and one station with triple expansion Corliss valve engines having attached Riedler automatic valve pumps.

In former years, when coal was used, the fuel consumption per water horse power per hour varied from 3.25 to 3.75 lbs.

LOCOMOTIVES.

Locomotives in use on sugar plantations are small engines, for three feet gauge of track; cylinders from ten to twelve inches diameter and from sixteen to eighteen inches stroke. The problem to be solved in fitting small locomotives with oil-

burning apparatus is complicated by the very wide variation



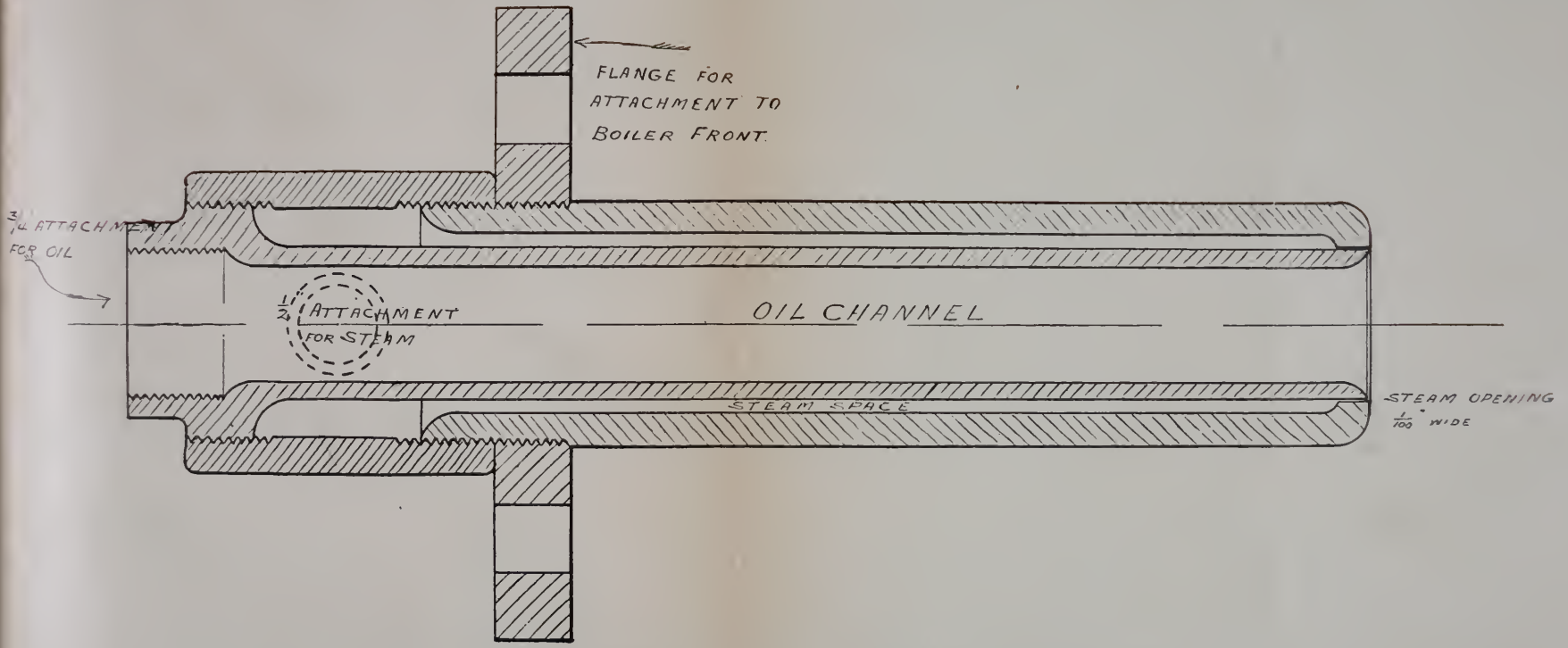


FIG. 1.—SKETCH OF ATOMIZER FOR CRUDE PETROLEUM. SCALE ½ FULL SIZE.

burning apparatus is complicated by the very wide variation of power required within small limits of time. This requires a burner that will furnish the necessary oil for combustion to keep steam at maximum demand; furthermore, the burner must be so arranged that the minimum amount of oil can be atomized by the minimum amount of steam required for atomizing. In any case, the steam required for atomizing oil in a locomotive boiler is a very much greater percentage of that produced by the combustion of the oil so atomized, than is the case in a stationary boiler plant; this is due to the constant variation in the load on the engine, when going up or down grades, picking up loads and dropping them off in the usual course of a day's work.

It is also necessary to keep the steam blower in the chimney going all the time the burner is atomizing, even with the engine standing, as a draft must be created to draw in a sufficient supply of air to the burners as commonly arranged, and also to carry off the products of combustion.

This all means a greater consumption of water in locomotive engines when using oil as fuel than when using coal.

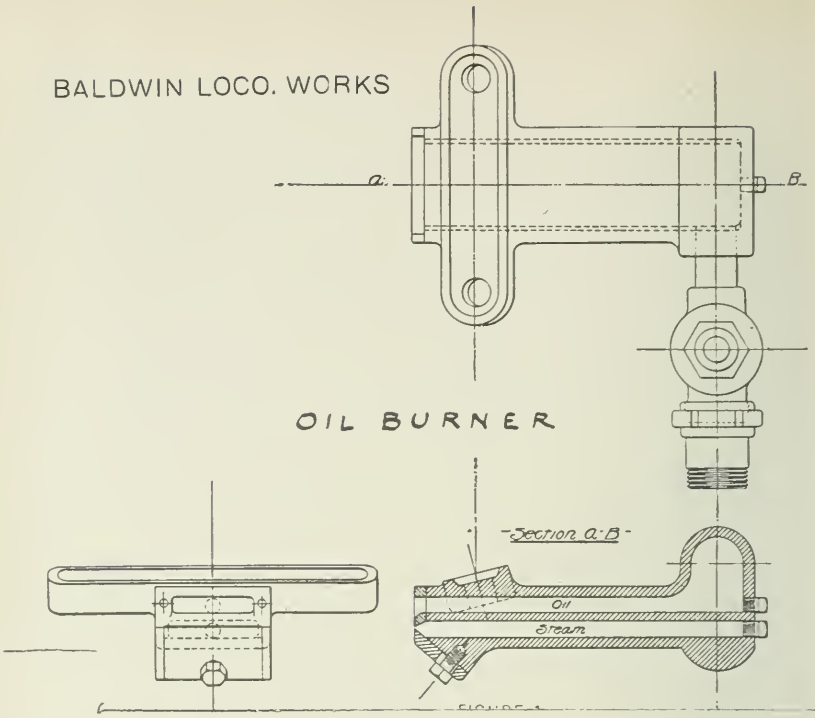
Nevertheless, there is a considerable saving when using oil, but not as great as that shown in stationary boilers.

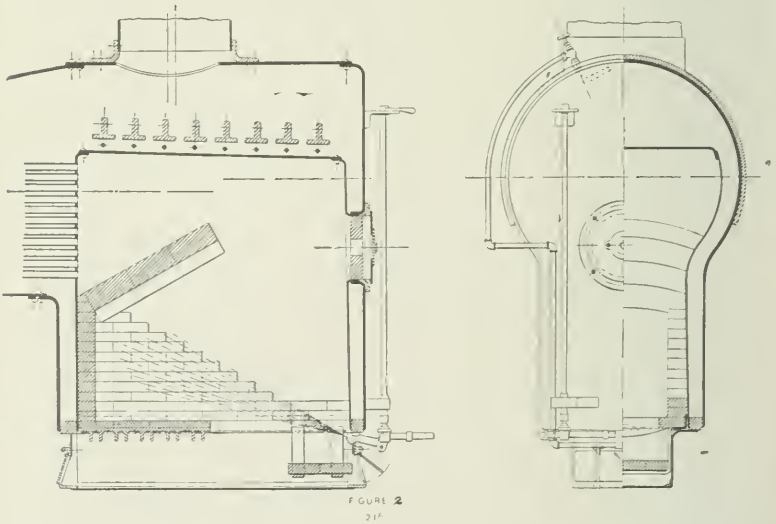
The results obtained in four locomotives, under the author's charge, employed in ordinary sugar plantation work is as follows :

Regular freight (weighed)....	45,000	tons.
Casual freight (estimated)....	5,000	"
Passengers (estimated)	2,200	"
Cars (weighed)	23,600	"
Total tons hauled, exclusive of engines and tenders.....	75,800	

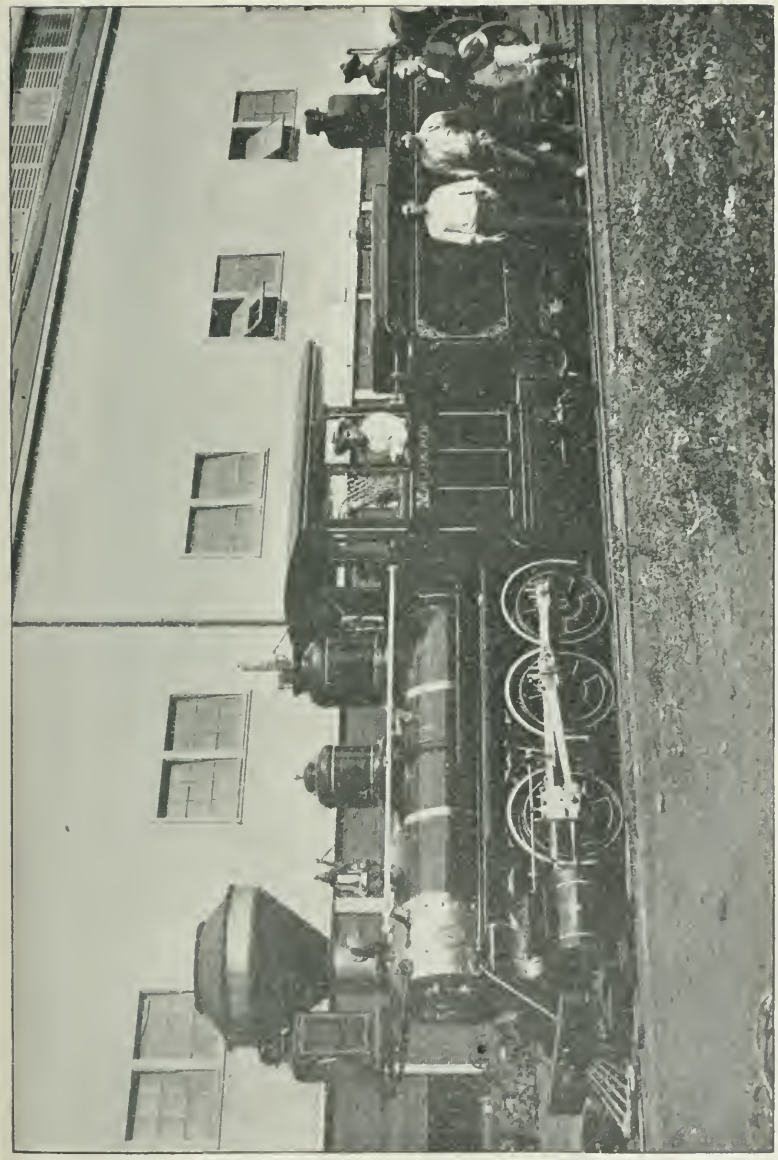
Miles run per day for each engine average—45.

Total miles run for all engines per month of 27 working days—4,860.





SKETCH OF OIL ATTACHMENTS ON LOCOMOTIVES



BALDWIN LOCOMOTIVE BURNING OIL.

Steepest grade, two and a quarter per cent.; trips per day per engine, average, 3.

Longest run without stops, about six miles.

Total crude oil consumed as fuel for month, 27,013 gallons.

Cost for fuel, $949.00.

This shows that each engine hauled on an average trip of fifteen miles in length, 234 tons of live and dead load, at a cost for fuel per trip of $2.92.

All the locomotives are fitted with oil-burning apparatus furnished by the Baldwin Locomotive Works Co., of Philadelphia, to whom the author is indebted for many useful suggestions when making the change.

Of the locomotives, two have cylinders, twelve by eighteen inches; driving wheels, thirty-six inches diameter; one has cylinders, nine by fourteen inches, and thirty inch driving wheels; and one has cylinders ten by fourteen inches and thirty inch driving wheels.

Two locomotives were made by the Baldwin Locomotive Works Co., and two by H. K. Porter & Co., Pittsburg.

The sketch from the Baldwin Locomotive Works Co. shows the method of applying the burner, and also a cross-section of the burner itself. The photograph shows an engine going out on its trial trip, steam is at one hundred pounds per square inch and is being raised to one hundred and thirty-five pounds, burner full on and no smoke visible.

It seems probable that a considerable improvement will yet be made in the results of oil burning accomplished in locomotives.

STEAM PLOUGHS.

Steam ploughs are heavy traction engines, fitted with winding drums set horizontally beneath the boiler and between the road wheels; they are worked in pairs, one engine stationed about 1,200 feet from the other and pulls a reversible gang plough hauled by a wire rope from the other engine, which is standing idle while the one is working.

These engines develop from thirty to forty horse power each, and a pair in good clear ground will go over about seven acres per day ploughed about fifteen inches deep.

In applying crude oil as fuel to such engines the problem is even more complicated than on locomotives; the oil containers on the ploughs are small and must be filled twice a day; this necessitates a small tank waggon travelling over ploughed ground; the water consumption is as is the case in locomotives, much increased by the use of oil, and as the water must be conveyed to the ploughing engines in tank waggons over the newly ploughed land, it requires extra teams and drivers and this expense may wipe out entirely the saving made by the use of oil as fuel as against coal.

The details of arrangement of furnaces, burners, etc., are the same for steam ploughs as for locomotives.

A summary of the foregoing shows that ordinary crude petroleum is an ideal fuel, its greatest gain over coal, however, is demonstrated to be in stationary plants, where the load on the boilers is constant and the adjustments of the burners can be made exactly.

Oil fuel has its place either where coal is dear and not particularly good in quality, or where oil is very cheap, as would be the case near oil fields.

THE NEED OF A PROVINCIAL MUSEUM IN ONTARIO.

By Dr. W. A. Parks.

In bringing this subject to the attention of the Institute it is not my intention to present a dissertation on the question of museums in general, but to attempt to interest the members in the hope that some action may be taken towards the establishment of a museum in the province of Ontario. The great value of a systematically arranged and properly displayed exhibit of the natural products of any country is thoroughly appreciated when a great exposition is engrossing public attention. The governments of Canada and of Ontario have spent considerable sums at different times to present to the eyes of the world a representative series of our natural products. Why should not the same attention be directed to the preparation of permanent exhibits of the same kind ?

It is with pleasure that we notice the Dominion Government moving in the right direction. The valuable collections of the Geological Survey will soon be housed in a suitable building under proper management. The museum at Ottawa will fill a long felt want, but it can scarcely be expected to answer all the demands of the different provinces. The mere distance alone makes it necessary for each province to possess a museum, in part a duplicate of that at Ottawa, but more especially representative of local products. Professor F. A. Bather, in an address to the Museums' Association at Aberdeen, in 1903, states that a museum fulfils three functions: Investigation, Instruction, Inspiration. The first of these functions consists in providing material for the special investigator, the research student, the savant. The second consists in presenting the natural history of the country to the eye of the college student and of the people in general. The third refers to the effect which must be produced by the contempla-

tion of the *best* in any given line of exhibit. To these three functions might be added a fourth, that of downright utility to the miners and manufacturers.

Toronto is the capital of Ontario, it is the great centre of population, it is the heart of the educational system of the province, it is the point where all of Professor's Bather's objects can be best achieved, yet the capital of the banner province of Canada is without a museum. There is no material for the investigator, no arranged series for the student and no inspiration for the general public.

The writer would not be narrow in regarding the future provincial museum, he would have it embrace the whole field of human activity and all branches of geological and biological science. An ideal museum should reach from chemical manufacture to the fine arts and from petrographic collections to archaeological curiosities. Before this Institute, however, the claims of such a museum would be out of place; we must confine our attention to that branch of museum work with which we are especially concerned. From our point of view the subject might well be presented under familiar heads:—

MINERALOGY.

For reference, for comparison and for study a complete collection of minerals is imperative. This should be supplemented by a collection of Canadian minerals, kept constantly up to date. Small cabinet specimens are not the only ones required; but large, rough pieces with the accompanying rock. We all know that beautifully crystallized cabinet specimens are not the kind of material commonly found in the field; the mining man and prospector would like to see the impure, dirty ore and rock that he encounters in his work. Material of this kind arranged on an economic basis, and above all, kept up to date, would be of incalculable benefit to the mining men of the province.

PETROGRAPHY.

The rocks of the various geological formations should be arranged so as to exhibit their petrographical characters, and

in addition, a second series should present the succession of these rocks in natural order and should be accompanied by labels pointing out the thickness of the various strata. Such material would be most valuable to oil and gas operators and to all engaged on the stratified series.

PALÆONTOLOGY.

A most urgent need is a complete exhibit of the fossils of the province. The value of such a collection to the scientific student is at once apparent. From our essentially economic standpoint it is important that mining men should have a means at hand to identify the age of the strata encountered. This can only be accomplished by giving them access to a well named and properly arranged series for comparison.

MINING AND METALLURGY.

The crude products of the mine should be supplemented by material to show every stage in the process of metallurgical treatment. Carefully prepared explanatory notes should accompany such an exhibit so as to present to the eye of the student, the miner and the metallurgist an illustrated compendium of the industrial treatment of ores and other products of the mine. This particular part of the work might be made to include certain phases of chemical manufacture, and I would suggest that the co-operation of the Canadian Society of Chemical Industry be asked in the matter.

Much as we might like to see the biological sciences and the fine arts represented, and represented they will be in time, our immediate concern is to take some steps towards the establishment of a museum of geology and mining in the Province of Ontario.

The greatest want is a suitable building. Once given a home and proper provision made for support, much valuable material could at once be put in position. The Bureau of Mines is possessed of valuable collections of economic minerals. The School of Practical Science has within its walls much of value. The University of Toronto possesses an

excellent series of minerals (the Ferrier Cabinet), a growing collection of fossils and considerable petrographic material. The Education Department is rich in archaeological specimens and curios. The department of biology of the University has a considerable collection of material in its especial field. Directly or indirectly all this material is the property of the government, yet it is so ill-housed, so separated and under such diverse control that its value is largely destroyed. In fact, instead of being an inspiration and a valuable exhibit of the resources of the country, the breaking up of specimens into little groups restricts their use to the persons immediately interested. Could the province do better than to erect a building for the proper reception and display of all this material ? Could anything be of more value to the geologist and to the active mining man ? Could a better inspiration be found for the creation of future generations of mining engineers ? I need not fall back on the somewhat unpleasant argument as to what other countries have done in this matter; we are rather tired of hearing of the advance of this state or that along some particular line. Let us not fall so far behind in the matter of museums that the term may be used as a reproach to us.

The creation of an adequate provincial museum is not a small matter or one that can be accomplished all at once. The details of any scheme of development would require much time and thought. Briefly, I may be permitted to state my ideas as to the general lines along which development would be the easiest. A building should be designed to fill the requirements of all branches commonly interested in museum display. This building should be so designed that it could be built in sections. The first section built should be that of geology and mining. The various departments should be under the control of the professors of those departments in the University, thereby saving the expense of especial curators.

At the present moment the Department of Geology has more material than can be housed in the University buildings.

A museum will positively have to be built, the matter is already before the government. As a member of the teaching staff of the University of Toronto I feel the absolute need of this building, I feel that we must have it, but I should be overjoyed to see a large provincial museum take the place of a merely departmental and academic one.

Ontario is a rich province, its population is nearly half that of the whole Dominion, its natural resources are enormous. It is high time that the example of all progressive states were followed and a thoroughly complete provincial museum established. In this connection it may be permitted to quote from the presidential address of Mr. B. E. Walker to the Canadian Institute in 1899. After a strong plea for increased expenditure on Dominion and Provincial surveys Mr. Walker says:—

"And as to public museums, the Dominion Government at Ottawa and each province, at its city of chief importance, should have a museum belonging to and supported by the people. These museums should contain exhibits of the metallic and non-metallic minerals of the country, both those of economic and merely scientific value, the forest trees, with the bark preserved, in say six feet sections, cut also and partly polished, and each specimen accompanied by a small map showing its habitat; the fresh water and sea fishes, mounted after the modern methods; the fur-bearing animals, the game birds, and the birds of our forests, fields and sea coast, many of them mounted so as to tell a child their habits at a glance; the reptiles, crustaceans, insects, plants, indeed as complete a record of the fauna and flora of the country as possible; the rocks of stratigraphic importance and all the varieties of fossils which can be gathered in this country; the archaeological and ethnological evidences of the races we have supplanted in Canada, and much more that does not occur to me at this moment. I should not like to suggest a limit of expenditure on such museums. I can only repeat that we are rich enough to bear the cost with ease, but we are not intelligent enough to see our own interest in spending the money."

Gentlemen, I have endeavoured to present a plea for a provincial museum in Ontario, because I know Ontario best, the same remarks will apply equally well to the other provinces. I know that these notes are rambling and disconnected, but I shall be satisfied if some discussion is stimulated and I should much like to see the Institute take some action towards bringing the matter before the provincial authorities.

DISCUSSION

Dr. Walker—In speaking on this subject, I would like to draw attention to the fact that the Province of Ontario is in a somewhat unique position. She has no systematic arrangement such as would be afforded by a museum for the display of her natural products. The establishment of a well-arranged museum would be of incalculable advantage to the province. Wherever I go, I find that mining men are usually generous in presenting specimens to public museums. In Victoria, the Province of British Columbia has a very attractive display of the resources of that province. The natural history collections are brought together, and the visitor has the advantage of finding these collections arranged in a systematic manner. I have spoken on this subject with Dr. Parks, and I quite agree with what he now has to say. It should not be forgotten that a museum is about the most profitable investment a government can make. The public take pride in sending specimens to the British Museum, because they know that whatever they send will be well and advantageously displayed. A Provincial Museum such as is suggested should be established in Ontario, might well be planned with a view to future extension, a start being made with natural history, economic product, and even include ethnological collections, and an Art Gallery. Of course, what we have chiefly in view to-day is the establishment of sections for the display of geological and mineralogical specimens.

Mr. Stairs—Reference may well be made to the fact that Nova Scotia has a very good museum, with a mining department, which latter was established two years ago.

Dr. Goodwin—Dr. Parks' discussion has been properly placed on a Canadian basis rather than on a provincial basis. Referring to the museum which is about to be built in Ottawa, one may remark, "better late than never;" and referring also to the necessity for provincial museums in all provinces, Ontario certainly cannot be congratulated on being forward in this very necessary work. A province with a large population, a province rich in universities, and also rich in minerals and other resources, certainly should have long ere this moved for a museum. It is one of the best investments which a country can make. With regard to the nature of a provincial museum, I think Dr. Parks has very well outlined that, and has shown lines along which a museum could be created and developed. It is truly wonderful how such material is accumulated. Everyone becomes interested in sending the best that he can find to such a place. I should like to add this, that the building of these museums and their furnishing with specimens should be undertaken just as early as possible, particularly from the point of view of mineralogy and geology. For this reason:—When mines and mineral deposits are discovered and opened up for the first time it is a matter of common experience that very usually we happen upon the best specimens of the materials which we wish to represent in our museums right at the start. I know a number of cases in which the very finest specimens of this sort have been discovered in Canada, and a good many of them have gone to enrich museums in the United States, because we did not feel we had representative institutions in Canada, or simply because we did not take enough interest in them to keep them at home. Let us keep for our own people the best we can produce.

The President—We have had a very interesting discussion upon this subject which Dr. Parks brought before us, and this paper, with the discussion connected with it, will be the

means of bringing the attention and interest of the legislature and government of Ontario to this very necessary step in the education of nearly everybody in the province. No doubt the need of it is great in such a large city as the capital of the great Province of Ontario. I would be glad if a committee was appointed to place it before our Provincial Government, or we might do that later on. We will give them our views first in the paper and discussions.

THE ARTESIAN AND OTHER DEEP WELLS ON THE ISLAND OF MONTREAL.

By Frank D. Adams, McGill University.

During the past fifteen years a large number of borings have been put down along the southeast side of the Island of Montreal for the purpose of obtaining water. Most of these have been located in the City of Montreal, but some of them are situated in the suburbs and district. In most instances large supplies of good water have been obtained, in other cases, however, the water obtained was saline in character, while in still other cases little or no water of any kind is found.

This source of water supply in the district about Montreal bids fair to assume an ever-increasing importance in the future, and it has therefore been deemed advisable to gather all the facts which it is possible to secure concerning the borings which have already been made, more especially as much of this information if not now obtained and recorded will be permanently lost, and at the same time by a study of the geology of the district to ascertain what light may be thrown on the character and origin of the subterranean water supplies, and the probability of obtaining water by further boring. It is of special importance to ascertain, if possible, whether any definite water-bearing horizon or horizons exist in the subjacent strata. If there be such water-bearing horizons, it is very important to ascertain their depth below the surface, since knowing this it will be possible to determine where and at what depth one could rely on obtaining water by boring. Investigations of this kind in many other districts, as is well known, has resulted in the discovery and development of water supplies of great extent and of inestimable value. If, on the other hand, definite water-bearing horizons prove to be absent, much may be learned with regard to the general

probability of securing water by drilling. Accordingly, for some years past the Geological Department of McGill University has been collecting information bearing on the question of the artesian water supplies of the Island of Montreal; nearly all the deep wells on the Island have been visited, and all data concerning them which it was possible to secure has been collected and tabulated. The borings have been made with the ordinary percussion drill, no diamond drill holes have been put down, and consequently no proper cores of rock have been obtained from the bore holes. In most instances no detailed logs of the borings have been kept, and no samples of the material obtained from the well have been preserved by the drillers.

Specimens from a few of the wells, however, have been secured, and have been of the greatest value in supplementing and extending the knowledge of the succession of the underlying strata obtained from a study of the surface geology of the district. All this information, together with detailed geological maps and sections of the district, and diagrams giving sections along many of the chief bore-holes, is presented in a report which is now being published by the Geological Survey. In this report the endeavor is made to present as complete a description as possible of every boring which has been put down on the Island of Montreal up to the close of the year 1903. Eighty-nine bore-holes are included in the list, which is believed to be complete. It is possible, however, that notwithstanding the diligent inquiries which have been made, a few wells may have escaped notice.

In the present paper it is proposed merely to present a general statement concerning the results of the investigation, those especially interested in the water supply in question being referred to the Report above mentioned for further details, if required.

With a few exceptions, the borings referred to have been drilled by Mr. Wallace Bell, of Montreal, and to this gentleman, as well as to his partner, Mr. William Bell, I am in-

debted for much information concerning them. I am also indebted to the owners of the various wells, who have in all cases readily supplied me with all facts in their possession concerning their respective properties.

Before considering the records of the artesian wells on the Island of Montreal, it may be advisable to review some of the conditions by which the occurrence of the underground water is affected.

It is well known that the rain and snow which fall upon the earth's surface is disposed of in three ways:

1. A portion of it drains off the land, finding its way through brooks and streams into the rivers and thus to the sea.

2. A second portion rises in vapor, and is returned to the heavens as mists and clouds.

3. Still another portion sinks into the earth's crust and disappears from view.

The relative proportion of the precipitation which is disposed of in these three ways varies greatly with the character of the surface and the climatic condition of the area on which the precipitation takes place, but it may be stated, speaking very generally, that in regions of temperate climate about one-third of the precipitation is disposed of in each of the three ways mentioned.

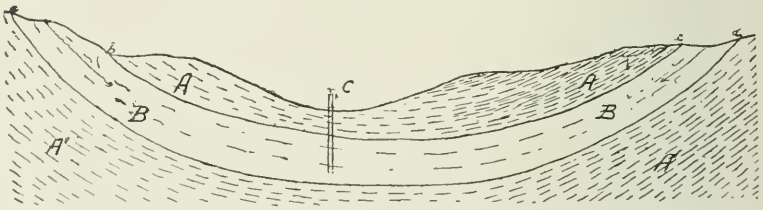


Figure 1. Showing a synclinal fold with a porous bed between two impervious ones.

That portion of the rainfall which sinks into the earth's crust here alone claims our attention. The water passes down through porous strata or in cracks and fissures, thus giving

rise to a system of subterranean water circulation, and finally comes to the surface again at some lower level in the form of springs, or passing out into the sea along the continental margins is lost in the waters of the ocean.

In some localities it is possible, by boring, to tap these underground water supplies, thus bringing water to the surface in the form of Artesian wells, which may be regarded as artificial springs. One simple case of this is shown in the drawing presented in Figure 1. Here certain beds of differing composition are seen interstratified with one another. The beds A and A^1 are clays or shales, while the bed B is sand and gravel or the more compact equivalents, sandstone and conglomerate. These rocks, originally laid down in horizontal beds, have been curved by pressure developed in the earth's crust, which curving has given to the area the form of a basin. The beds are tilted on either side at such an angle that they are exposed on the surface with the outcropping edge of B at a greater elevation than the surface of A. A. and A^1, on account of their composition and texture, are practically impervious to water, and being in direct contact with the pervious or porous bed B, they act as confining beds which prevent the water which passes through B from escaping either upwards or downwards. These three beds present the features found in one class of channels through which underground water moves. The water enters the bed B at its outcrops ab and cd, and flows down the dip of the stratum. If, however, the bed B is tapped at a point C by a boring, the water will rise to the approximate level of the ground water in B at ab and cd. The supply of water thus obtained will constitute an artesian or flowing well. If, however, the upper bed A, from extensive fissuring or a somewhat porous texture, be not water-tight, the pressure will be relieved, and the water will follow the more easily accessible channels through A to the surface, thus lowering the efficiency of the well at C. The head has in many instances been so reduced that the water will not rise to the surface, but must be pumped. In such cases as these there must be a sufficient rainfall, and

where the porous bed B outcrops there must be a considerable area of the bed exposed. For instance, if the rainfall is the same at both the outcrops of B on the opposite sides of the basin, then ab, being more extensively exposed than cd, will furnish a greater supply of water.

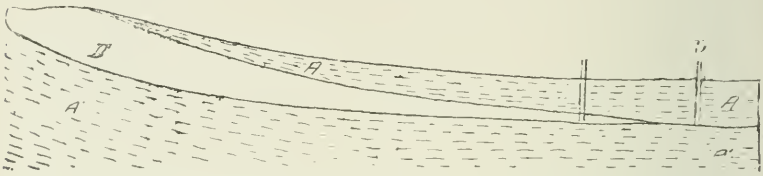


Figure 2. Showing the pinching out of the porous bed B (modified from Darton).

Another type of structure, and probably a more common one than that previously discussed, is shown in Figure 2. In this case there is no basin, but a monocline or a long slope of the beds in one direction. The porous bed B thins out and finally disappears, with a concurrent thickening of the impervious bed A. In such an instance a boring at C would be successful, while at D no water would be obtained. This structure obtains throughout the great coastal plain which forms the eastern margin of the United States, from New Jersey southward, and from it immense supplies of artesian water are obtained.

Figure 3. Showing effects of surface drainage on a porous bed (after Darton).

Again, the character of the surface drainage may be such as to interrupt the passage of underground waters, as shown in Figure 3, where a cross valley interrupts the water-bearing stratum. Little or no water would be obtained at B, while at A on the lower side of the valley a successful well might be sunk. The water in the upper part of the bed about B would

escape and probably form springs along the valley side at C. This is a condition frequently met with along the western border of the coastal plain in Maryland and southern Virginia.

Another case which is sometimes found is illustrated by Figure 4. Here the water-bearing zone, instead of being broad and continuous, is broken up into several narrow beds, which are flatly lenticular in cross section. Boring would give satisfactory results at C, but negative ones at D.

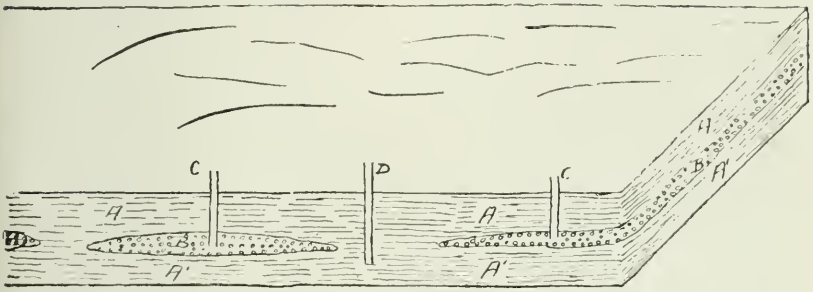


Figure 4. Showing the discontinuity of the porous stratum (modified after Darton).

Many other types of underground drainage might be mentioned, but the above will suffice to explain the main conditions which affect underground waters traversing porous beds.

Artesian waters have, however, sometimes been obtained in districts which are underlain by rocks of a more massive character than those which we have been considering, such as compact limestones, granitic rocks and crystalline schists. The underground water in these cases flows through cracks and fissures and not through porous beds. This type of subterranean conditions is rudely represented in Figure 5, where the rocks at A are massive and crystalline, overlain by compact limestones, B. The gathering ground is the outcrop of these rocks at a, b, c, and the irregular lines indicate the courses of the subterranean water circulation which takes place through fissures. The supply of water in this case will not depend upon the amount of rainfall alone, but will be influenced by the extent of the subterranean erosion which the

country has undergone, by which the fissures and joint planes have been enlarged and deepened, so as to permit the passage of large quantities of water along their course. In this instance a well sunk at C would tap one of an upper series of fissures, and the capacity of the well would be further increased if the boring were extended to the lower level at C. On the other hand, the boring at D would miss the water-bearing fissures by perhaps only a few feet, and would consequently be dry, as would also that at F. At E, water is obtained from a lower series of fissures. The materials held in solution by the water in such a district would probably vary considerably, the variation depending upon whether the source of supply was in the crystalline rocks or in the limestone, as well as on the length of the underground channel through which the water had passed.

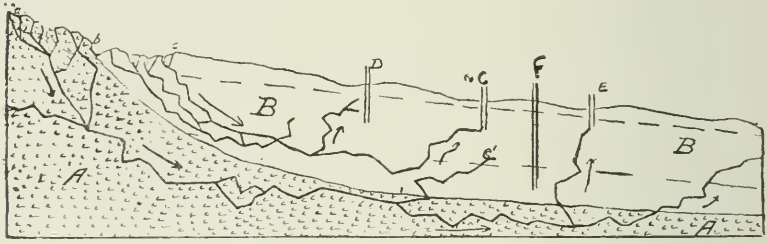


Figure 5 Showing the course of underground waters along fissures.

In the case of waters whose underground flow is through fissures, a great variation must always be looked for in the height to which the waters will rise, not only in adjacent holes tapping different sets of fissures whose gathering grounds may be at very different elevations above sea level (as a, b, c, in Figure 5), but also in holes which tap different fissures of the same series. It will thus be seen that in such an area no definite predictions can be made concerning the finding of water, owing to the irregularity in the course of the water-bearing fissures. Even if the fissures be only a few feet apart the number of unsuccessful wells will still be large. But in the case of dry wells, as D, it might be possible by shattering the wall rock at some point along the course of the bore-hole,

making use of explosives, to open up a communication with some adjacent fissure, and thus secure a supply of water.

A striking example of waters occurring in this manner is afforded by the islands off the coast of Norway. From the old crystalline country rock there, large supplies of water are in many places obtained by putting down deep holes which, meeting underground fissures through which water is passing, afford a passage for the water to the surface.

Figure 5 also illustrates in a general way, as will be shown, the underground conditions which prevail on the Island of Montreal where the bore-holes are put down in heavily bedded limestones and where no constant and definite water-bearing horizons have as yet been reached. A further complexity, however, is introduced in this district by the existence of Mount Royal, the root of an old volcano, which, with the swarm of dykes or walls of igneous rock connected with it, serves to make the course of the underground waters still more devious.

The term, "Artesian well," is, properly speaking, used only to designate a well which flows without being pumped, the term being derived from the French province of Artois, where wells of this nature, put down in the twelfth century, first attracted widespread attention in Europe. Similar wells, however, had long before been known in China, while others in the Libyan desert are believed to be not less than 4,000 years old. In fact there are few parts of the world where the geological conditions are better suited to Artesian boring, or where more abundant supplies of water can be had, than over a great part of the North African desert. Under the burning sand here, at a depth of 300-400 feet, there are abundant supplies of water running through pervious sandy strata from the richly watered district of the Soudan to the south, but held down by an impervious limestone cover. It is only necessary to pierce the latter to obtain for the water a passage to the surface, and the French engineers have turned great stretches of the desert into cultivated land by water obtained in this way.

Of recent years the Geological Survey of the United States has devoted a great deal of attention to the subject of Artesian water, and immense supplies of excellent quality have been obtained in many parts of the Union to the great benefit of its inhabitants. In New South Wales, Queensland and other parts of Australasia also, search for Artesian water has resulted in securing immense supplies, and throughout the world generally attention has been strongly directed to this source of one of the chief requirements of life.

The force with which the water issues from an Artesian well, and the height to which it will rise above the surface, is dependent primarily upon the height of the gathering ground above the level of the top of the boring. Other things being equal, the greater the difference in the level the higher will the water rise. In the case of certain of the Artesian wells on the plains of Dakota, where the water has its source in the Black Hills and the Rocky Mountains, the water issues with a pressure of as much as 177 pounds per square inch. One Artesian boring at Woonsocket, South Dakota, throws a 3-inch stream to a height of ninety-seven feet. In many parts of this field the waters are known to run in the porous subjacent fields for several hundred miles before being brought to the surface. There are many Artesian wells in various parts of the world which yield half a million to a million gallons every twenty-four hours, while some of the great Queensland wells yield 2,000,000, 3,000,000 and even 4,000,000 gallons per diem. This yield, however, is exceptional.

In the case of many wells the pressure is barely sufficient to cause an overflow, while again in many instances wells must be pumped in order to bring the water to the surface. Wells of this last class, while often yielding an abundant supply of water, are not, properly speaking, Artesian wells, and to this class belong almost all the wells in the Island of Montreal, only six of the eighty-nine above mentioned being actually flowing wells, although in many others the water rises to within a few feet of the surface.

Artesian water has comparatively little value unless it be fresh and sweet, but in many cases the water obtained from Artesian borings is saline and not potable. In other cases Artesian waters are very hard, owing to a large content of lime salts. This arises from the fact that the waters have, during their underground journeys, passed through beds containing salt, gypsum, limestone or other soluble materials, and have taken these into solution. In some cases also the waters have penetrated into the earth's crust to such a depth that they have become heated by increased proximity to the central portion of the earth, and, rising again to the surface, produce warm springs. These, as well as many cold waters, frequently contain mineral waters in solution which are distinctly beneficial and not harmful, and thus the mineral waters, so largely used for medicinal purposes, result.

In the case of the district about Montreal, as will be shown, all these classes of waters have been obtained by deep borings, although the water has not penetrated into the earth's crust in any case to a sufficient depth to be noticeably warm when it rises again to the surface.

In the district embracing the Island of Montreal, and the country to the north of it, there are two distinct and dissimilar tracts of country, each having well marked topographic features. These are the Laurentian Plateau to the northwest, composed of very ancient crystaline rocks, and the Palaeozoic plain to the south. The Laurentian Plateau is a rolling, comparatively hilly, and rugged country. At its southern margin it has an average elevation of about six hundred feet above sea level, while fifteen miles further north the average elevation reaches 1,000 feet, and twenty-five miles still further north the country frequently attains an elevation of 1,900 feet, while some hills rise still higher, the most notable of these being Trembling Mountain, the summit of which is 2,380 feet above sea level. The valleys are more or less filled with drift, and in the hollows are numerous lakes, the abundance of the latter being one of the most characteristic features of the Laurentian Highlands.

The Palaeozoic plain is practically flat, and thus offers a strong contrast to the topography of the Plateau. It stretches from the margin of the Laurentian country, which is about thirty miles to the north of the City of Montreal, southward, embracing the country between the Laurentian Highlands and the St. Lawrence, as well as the whole of the Island of Montreal. The average elevation of this plain in the vicinity of Montreal is about 100 feet above sea level, but there is a gentle rise towards the northwest, which gives the plain at its junction with the Plateau an elevation of about 300 feet; the whole area is drift-covered, and forms farming land of exceptional fertility.

The continuity of the plain is broken only by Mont Calvaire at Oka and by Mount Royal rising behind the City of Montreal; the former is an outlier of the Laurentian Plateau —an ancient island in the Palaeozoic sea—and has an area of about thirty square miles, while the latter is the most westerly of a line of old volcanoes and laccolites, known as the Monteregian Hills,[1] which cut the Palaeozoic rocks of the plain.

The following table presents the order and succession of the formations underlying the plain in question, as determined by Logan. The thicknesses given for the several formations are those which were obtained from a study of the outcrops of the various formations in the district:

PLEISTOCENE:	
Drift	Varies greatly.
ORDOVICIAN:	
Lorraine shales and sandstone	up to 2,000 feet.
Utica shale	100 to 300 feet.
Trenton Group (Limestones)	about 600 feet.
Chazy limestone	300 feet.
Calciferous dolomite	450 feet.
Potsdam sandstone	700 feet.
LAURENTIAN:	
Gneiss, anorthosite, etc.	

(1) Adams, F. D., The Monteregian Hills; a Canadian petrographical province. Journal of Geology, April-May, 1903.

No.	Name of Owner.	Location.	Depth in ft.	Diameter of hole in inches.	Capacity per diem in gallons.	Water level in feet.	Character of water.	Remarks.
1	R. B. Angus	St. Anne de Bellevue	222	4½	48,000	-12	Good	
2	Armstrong & Cook	Montreal West	500		10,000	-100	Hard, slightly sulphurus	Rock 50 feet from surface.
3	Belding, Paul & Co	On Canal, near Seigneur St. Bridge	548	6	91,000	-10	Hard	Rock 64 feet from surface.
4	Bushnell Oil Co.	Ville St. Louis	305	4	1,000†	- 20 to -30	Hard, slightly sulphurus	Rock at surface.
5	C. S. Campbell	Dorval	480	4¾	12,000	-20	Good	
6	Canada Brewing Co.	218 DeLorimier Avenue	580		24,000	-28	Good	Rock 50 feet from surface.
7	The Canada Malting Co.	St. Henri (lot 104,781)	678	6 & 4¾	12,000	-6	Good	Water was obtained at 300 feet, rock 32 feet from surface.
8	" "	" "	506		16,800	-30	Good	Rock 18 feet from surface.
9	" "	Abattoir site, near St. Henri	1281	4¾	18,000	-10	Highly saline	Water at 350 feet and no further supplie below. Rock 30 feet from surface.
10	The Canada Sugar Refining Co.	150 Montmorency St	312		120,000	-18	Good	Rock 70 feet from surface.
11	Canadian Pacific Railway	Hochelaga	539	8 & 6	240,000	-6	Good	Rock 12 feet from surface.
12	" " "	"	557	8 & 6	120,000	-8	Good	Rock 13 feet from surface.
13	" " "	Outremont	410	5½ & 4	192,000	-8	Hard&sulphurus	Rock 25 feet from surface.
14	Convent of the Precious Blood	Notre Dame de Grace	296		36,000	-20	Good	Rock 42 feet from surface.
15	M. Cousineau	St. Laurent	128		abundant	†7	Rather hard	Rock 40 feet from surface.
16	Dr. R. Craik	Petite Cote, Lot 192	305	4	120,000	-10	Soft	
17	Mr. Curran's Farm	Between St. Laurent & Back River	260	6	24,000	-6	Pure	Rock 16 feet from surface.
18	The Thomas Davidson Manufacturing Co.	187 Delisle Ave., Ste. Cunegonde	150	6	72,000†	-8	Hard	Rock 50 feet from surface.
19	Dawes & Co	Lachine	1003		abundant	-10	Saline	
20	W. B. Dickson	Longue Pointe, Lot 21	170			-13	Saline and sulphurus	Rock 100 feet from surface.
21	The Dominion Wadding Co.	Corner William and Vinet Sts., St. Cunegonde	175	6	abundant	-8	Pure	Water at 160 ft. Rock 90 feet frosm urface.
22	William Dow & Co	186-188 Colborne St	360	4¾	24,000	-50	Not sulphurus	
23	" " "	" "	420	4¾	to small to be of any value	-40		
24	" " "	" "	430	4¾	60,000	-30	Slightly sulphurus	
25	" " "	Same property—cor. Inspector St.	830	4¼	hardly any water			
26	Alex. Drummond	Petite Cote	500		8,400	-50		Rock 5 feet from surface.
27	Sir G. A. Drummond	Beaconsfield	425		36,000	-10	Hard	Rock 10 feet from surface.
28	J. N. Drummond	Petite Cote, lot 195	223		24,000	-25	Soft, slightly sulphurus	
29	H. A. Ekers	Petite Cote, Lot 208	325		14,000	-33	Rather hard	
31	Ekers' Brewery	409 St. Lawrence St.	600		25,000	-10	Good	Rock 70 feet from surface.
30	Excelsior Woollen Mills	967 Ontario St	812	6 & 4	8,000	-100	Good	Water obtained at about 600 feet.
32	" " "	" "	754	10 & 6	86,000	-20		Rock 35 feet from surface. Some water at 500 feet; further supply at 740 feet.
33	" " "	" "	300		no water			
34	The Fenlin Leather Co.	141 Frontenac St	1025		to small to be of any value (4800)			Rock 60 feet from surface.
35	M. Galibert	929 St. Catherine St	454	4	25,000	-5	Good	Rock 56 feet from surface.
36	H. Gatehouse	808-810 Dorchester St	750		20,000	-30	Good	Rock 46 feet from surface.
37	Globe Woollen Mills	219 DeLorimier St	410		65,000	-10	Hard	Rock 35 feet from surface.
38	The Gould Cold Storage Co.	Grey Nun and William Sts	1301		10,000	-40	Good	Rock 73 feet from surface. All the water obtained was struck at 360 feet.
39	" " "	" " "	500		none			
40	A. Goyer	Frontenac St	375	4¾	9,000	-10	Soft	Rock 30 feet from surface.
41	F. Goyer	Cote des Neiges	250	4¾	72,000	-10	Very hard	Rock 25 feet from surface.
42	M. Grosboyau	1675 Papinean Ave	350		abundant	-12	Soft	Rock at surface.
43	Chas. Gurd	39 Jurors St	512		800 without pumping	0	Sulphurus	Water at 440 feet and at 512 feet; 4,000 gallons can be pumped.
44	Mr. Hampson	Longue Pointe, lot 40	502					
45	A. Hobbs	Outremont (back of C.P.R. Round House)	240	6	48,000	0	Saline and sulphurus	Rock 5 feet from surface.
46	Edward Hughes	Cote St. Michel	75		19,000	-20	Good	Rock at surface.
47	Laing & Sons	Cor. St. Catherine & Parthenais Sts.	325		36,000	-30	Soft	Rock 56 feet from surface.
48	Laurentian Baths	208 Craig St	280	6 & 4¾	40,000	†20	Hard	Rock 60 feet from surface.
49	Laurie Engine Company	1020 St. Catherine St	300	6 & 4¾	72,000	-15	Soft, faint iron taste	Water at 150 feet. Too hard for boilers.
50	" " "	" "	700		no water			
51	Longue Pointe Asylum	Longue Pointe	2000		9,000		Good	Rock 4 ft. from surface. All water obtained was struck at 300 feet.

47	Laing & Sons	Cor. St. Catherine & Parthenais Sts.	325		36,000	-30	Hard	Rock 56 feet from surface.
48	Laurentian Baths	208 Craig St.	280	6 & 4¾	40,000	†20	Soft	Rock 60 feet from surface.
49	Laurie Engine Company	1020 St. Catherine St.	300	6 & 4¾	72,000	-15	Hard, faint iron taste	Water at 150 feet. Too hard for boilers.
50	" " "	" "	700		no water			
51	Longue Pointe Asylum	Longue Pointe	2000		9,000		Good	Rock 4 ft. from surface. All water obtained was struck at 300 feet.
52	Lovell & Christmas	63 William St.	612	6	60,000	-30	Slightly sulphurus	Rock 62 feet from surface.
53	A. Martin	Lachine, lot 1010.	740	6	2,400	-11	Very hard	Rock 65 ft. from surface. Water at 460 ft., associated with gas.
54	A. S. & W. S. Masterman	2082 Notre Dame St	800		72,000	-10	Sulphurus and slightly saline	Water at 750 ft. Rock 68 ft. from surface.
55	Mrs. J. McIntosh	Cote St. Michel.	120		14,000	-5	Soft, slight iron & sulphur taste.	
56	J. H. R. Molson & Bros.	1006 Notre Dame St.	674	8½ & 4¾	112,800	-24	Saline	Rock 83 ft. from surface. Water at 420 ft.
57	Montreal Brewing Co	1334 Notre Dame St.	502	4¾	126,000	-36	Hard	Rock 80 feet from surface.
58	Mount Royal Cemetery	Near Crematory	354	4¾	36,000	-25	Good	Started on rock surface.
59	Montreal Cold Storage Co.	610 St. Paul St.	1020			0	Sulphurus	Pocket of gas struck. Rock 60 ft. from surf.
60	The Montreal Gas Co	Hochelaga	1850		none			
61	" "	" "	2550		none			
62	" "	Ottawa St.	1050		no water			Rock 90 feet from surface.
63	Montreal Hunt Club	Outremont	226	6	36,000	-10	Good	Started on rock.
64	The Montreal Locomotive & Machine Co	Longue Pointe.	514		29,000	-25	Somewhat sulph.	Rock 27 feet from surface.
65	Montreal Milling Co	Park Avenue, Outremont.	345	5	40,800	-25	Very hard	Rock at surface.
66	Mount Royal Park	"Park Well"	66	4	12,000	0	Good	Rock 4 feet from surface.
67	Montreal Weaving Co.	595 Clarke St.	420		12,000	-125	Soft	Rock 5 feet from surface.
68	G. Nantel	Cote des Neiges	600		abundant	-10	Good	Rock 5 feet from surface.
69	Outremont Milling Co.	Outremont.	335	4	43,000	-25	Very hard	
70	Judge Pagnuelo	Pagnuelo Avenue	700		7,000 (about)			
71	Mrs. Quiggley	Longue Pointe.	100		4,800	-9	Rather hard	Rock 90 feet from surface.
72	A. Ramsay	Inspector St.	800		48,000 (about)	-14	Hard	
73	A. Ramsay	Westmount.	880		15,000	-18	Rather hard	Water was struck at 700 feet.
74	M. Rheaume	Carriere St.	300		24,000	0	Rather hard	Rock 10 feet from surface.
75	Rowan Bros	618 Beaudry St.	600		120,000	-60	Good	Rock 70 feet from surface. Used for aerated waters.
76	The Royal Golf Club.	Dixie.	450		28,800	-15	Good	Rock 37 feet from surface.
77	The Salvador Brewing Co.	617 St. Paul St.	550	4½	too small to be of use (8,000)			Rock 62 feet from surface.
78	Sault au Recollet College	Back River.	490	6	12,000	-30	Soft	Rock 35 ft. from surface. Hard water struck 100 ft. from surface. (See description.)
79	Shawenegan Water & Power Co.	Maisonneuve	1017		too small to be of any value (4,800)			Rock 26 feet from surface.
80	Sisters of Providence	Notre Dame de Grace	320	4½	48,000		Good	Rock 22 feet from surface.
81	Stanley Dry Plate Co	613 Lagauchetiere St.	1300	4¾	8,400	-30	Good	Rock 40 feet from surface.
82	St. Laurent Convent	St. Laurent.	250		abundant	0		
83	St. Laurent College	"	487		10,000	-13	Soft and slightly sulphurus	Rock 31 feet from surface.
84	Mr. Stewart	Petite Cote, lot 195.	223		10,000	-25	Soft and slightly sulphurus.	
85	T. A. Trenholme	Cote St. Pierre, lot 141.	185		6,000	-25	Good	Rock 100 feet from surface.
86	T. A. Trenholme	Thorn Hill, Cote St. Pierre.	175		abundant		Pure	Rock 75 feet from surface.
87	Turkish Baths	140 St. Monique St.	1550		4,000-5,000	†6	Soft and slightly sulphurus.	Rock 50 feet from surface.
88	Viau et Frère	Maisonneuve	1500		5,000	*10	Saline and sulphurus	Rock 90 ft. from surface. Good water at 450 ft.; sulphurus water at 1,190 ft.
89	The Wire & Cable Co.	233-241 Guy St.	1055	6 & 4¾	72,000	Rises to surface	Hard	Rock 57 ft. from surface. Most of the water obtained at 960 ft. None found lower.

The Ordovician strata of the plains dip at a low angle away from the Laurentian Plateau, in a southerly direction.

In the accompanying statement, a list of all the borings which have been put down on the Island of Montreal, together with their depth, amount and character of water yielded by them, etc., is set forth in tabular form. In this, the waters are referred to as being in some cases Potable Water, in other cases Sulphuretted or Saline Water, while some of the wells are stated to be Dry. This classification is more or less arbitrary, for some of the waters are but slightly sulphuretted, and lose their odor on standing for a time, while others are highly charged with sulphuretted hydrogen. It is also difficult, especially in the absence of detailed chemical analyses, to determine in some cases whether a water should be classed as Saline or Potable. In the Report referred to, however, the analyses of all waters which have been chemically examined is given, and their precise character is thus set forth.

The term "Dry Well" is also one which might be used in different ways. None of these wells are absolutely dry. In all cases enough water oozed into the holes to allow the boring to be readily carried on; such bore-holes, however, although wet, yield no supplies of water which can be pumped. Other wells, again, yield two or three thousand gallons a day, a quantity which may be sufficient for the very moderate needs of a farmer for instance, but which would be quite inadequate for the requirements of a large manufacturing establishment; in fact, a well which will not yield over 5,000 gallons per diem is considered by the well-drillers to be a "Dry Well."

When a well is drilled, its capacity is determined by pumping it for several hours, and thus ascertaining the amount of water which it will yield. The values, given as "capacity per diem in gallons" in the accompanying table, are arrived at by taking the number of gallons thus pumped per hour, and multiplying them by twenty-four. The capacity thus stated may, therefore, in some cases be in excess of the actual

per diem capacity of the well, but the amount of water stated by the drillers to have been actually pumped in the trials made on the completion of the well is given in the Report in each case where a trial was made, and may there be ascertained. The capacity of many of the wells, however, has not been actually determined. In certain cases, if the well yielded the small amount of water required, this was considered to be quite satisfactory, and no test as to the full yielding power or capacity of the well was made. In these cases it is impossible to apply the well-drillers' definition. It has, therefore, been considered best to use the term "Dry Well" in the sense of a well which would not afford any supply of water, but in calculating the proportion of wells which give an adequate supply of water, as compared with the total number of wells put down, an adequate supply is considered to be 5,000 gallons per diem.

Chemical Composition of the Waters.

Most of the waters, as has been shown, are potable, but some of them are hard, owing to a considerable content of lime or magnesia salts, and are therefore unsuitable for use in steam boilers. Others, however, are soft, and adapted for such use. Some few, on the other hand, are impregnated with sulphurous compounds or are too saline in character to be of use except for cooling purposes. As has been mentioned, a thoroughly satisfactory comparative study of the composition of the various waters cannot be made, owing to the fact that those of which analyses exist have been analyzed by different chemists who may have, and in all probability have to a certain extent at least, followed different plans in combining the different acids and bases, the amounts of the several acids and bases actually determined not being stated. The analyses, furthermore, have been made merely for technical purposes, and are in most cases incomplete. A comparative examination of them, however, brings out some interesting points.

Dr. Sterry Hunt, many years ago, made a somewhat extended study of the waters of the mineral springs which at many points rise through the unaltered palaeozoic strata of the provinces of Quebec and Ontario* and found that these might be divided into six classes, as shown in the accompanying table:

Class I. Saline waters containing sodium chloride with large proportions of calcium and magnesium chlorides, sometimes with sulphates. Calcium and magnesium carbonates are present only in very small quantities, or are altogether wanting.

Class II. Saline waters which differ from the first in containing beside sodium, calcium and magnesium chlorides, considerable proportions of calcium and magnesium bicarbonates, the latter carbonate usually predominating.

Class III. Saline waters which contain besides sodium chloride, a portion of sodium carbonate, with calcium and magnesium bicarbonates.

Class IV. Waters in which sodium carbonate preponderates. They contain but a small proportion of sodium chloride, and generally hold a much smaller amount of solid matter than the waters of the previous classes.

Class V. Waters containing a large proportion of free sulphuric acid.

Class VI. Neutral saline waters in which calcium, magnesium and alkaline sulphates predominate, chlorides being present only in small amount.

The waters from the deep wells of the Montreal district cannot, of course, in the majority of cases be classed as mineral waters, being for the most part of potable quality, but those among them which are saline waters can be so classed, and all of them rising from the same great plain as the waters studied by Dr. Hunt might be expected to possess the same general characters in respect of the nature of the dissolved materials, although containing these in lesser amount.

*Chemical and Geological Essays, p. 157.

An inspection of the analyses given in this Report will show that there are among them no representatives of Dr. Hunt's classes I and V, while some of the waters do not seem to be referable to any of the classes which he has established, but to present intermediate characters.

Class II is represented by Messrs. A. S. & W. S. Masterman's well, although the water is not a very highly saline one.

To Class III is to be referred the water of the well put down by Messrs. Belding, Paul & Co.

Several of the waters are clearly referable to Class IV of Dr. Hunt's series, being characterized by a predominance of sodium carbonate. Of these, the water of the Laurentian Baths, that of the Montreal Locomotive and Machine Company, that of the Canadian Pacific Railway shops at Hochelaga, and of Mr. Galibert's well may be instanced. The water obtained by the Wire and Cable Company belongs to this class, although it contains, in addition to the sodium carbonate, a considerable proportion of calcium carbonate and some magnesium carbonate, thus resembling the water from St. Ours, analyzed by Dr. Hunt.

Class VI is represented by the water obtained by Messrs. Dawes & Co., at Lachine.

The waters from the well owned by Messrs Viau & Frere and that of Messrs. J. H. R. Molson & Brothers, on the other hand, are not referable to any of Dr. Hunt's classes, containing as they do large proportions of sodium chloride and sodium sulphate, with smaller amounts of calcium or magnesium carbonate; the latter water which is much less saline than the former, containing in addition a notable quantity of sodium carbonate. In the case of the Viau well, however, as mentioned below, it is well known that water enters the bore-hole at two distinct levels, the two waters differing in character.

Among the waters of the first four classes, Dr. Hunt considers the chlorides of the alkalies and alkaline earths (calcium and magnesium) which they contain, to have their origin in the limestones of the underlying palaeozoic strata, from the

Potsdam to the Trenton inclusive; while the sodium and potassium carbonates he believes to be derived from the argillaceous sediments which make up the Utica and Hudson River formations, these sediments containing alkaline silicates whose slow decomposition yields to the infiltrating water the alkaline carbonates and silicates which characterize the waters of Class IV.

The waters of the latter class, however, on the Island of Montreal cannot find their origin in strata of these ages for the borings all start in much lower rocks. If they derive their alkaline carbonates from shales, it must therefore be from the shaly beds interstratified with the Trenton or Chazy limestones, of the same age as those which Hunt supposes to be the source of these salts in the waters of the Caledonia and Fitzroy Springs of the Ottawa Valley.* In confirmation of this, it will be noted that the several wells above mentioned as affording the soft alkaline waters of Class IV are all comparatively shallow borings, ranging from 266 feet to 567 feet in depth.

As an evidence that the different classes of waters have their origin in different strata, Dr. Hunt further mentions that springs which are unlike in composition are often found in close proximity and apparently rising from a common fissure or dislocation; and he mentions among others a case in the Seigniories of Nicolet and La Baie du Febvre, where six springs rise through the Utica shale along a line in a distance of about eight miles. Of these, two belong to Class II, two to Class III and two to Class IV. These last Dr. Hunt considers to be probably derived from the shales, while the others have their source in the underlying limestones, and are more or less modified in their ascent.* A somewhat similar diversity of origin must be ascribed to the waters of the Montreal district, where an equally wide range in composition is presented in an area which is much more limited in extent. As has been mentioned, the highly saline waters here usually

* Chemical and Geological Essays, p. 157.

come from the deeper wells, and an excellent case in point is afforded by the boring put down by Messrs. Viau & Frere, at Maisonneuve, in which "good water" was struck at 450 feet which rose to within ten or twelve feet of the surface, but the boring being continued to greater depths in the hope of obtaining gas, highly saline and sulphurous water was met with at 1,497 feet, which, mingling with that first encountered, rose to the surface and overflowed at the rate of 5,000 gallons per day.

Much additional information regarding these waters, bearing upon the question of their composition in relation to the depths from which they rise, will undoubtedly be accumulated as time goes on, additional wells are bored and a greater number of the waters are analyzed.

Another point on which additional information may be looked for is the question as to whether any change will be observed in the character of the water yielded by a single well as it continues to be pumped for a series of years. The only well in the district from which any information has been obtained on this point, up to the present time, is that put down by Messrs. Robert White & Co., at the Laurentian Baths. Four analyses of this water, taken at intervals during a period extending over twelve years, have been given on page 47. A consideration of these will show that, while the total amount of dissolved matter has varied considerably in different years, the relative proportions of the several salts held in solution by the water was not, on the whole, altered much. There is, however, on the whole, a slight falling off in the amount of sodium carbonate and a slight increase in sodium sulphate present, as the years have passed.

General Conclusions.

From the examination of the available data in connection with the many wells which have been sunk on the Island of Montreal, it seems certain that there is no distinct water-bearing horizon in the form of interstratified permeable beds.

The water passes through the limestone series in large amount, following underground channels which have the form of irregular fissures. These fissures no doubt result from the enlargement of joint and bedding planes or of irregular cracks in the limestone, by the solvent power of the waters passing through them. These enlarged fissures evidently form an irregular and complex system of water channels passing through the limestones, and occur at all depths hitherto reached by boring. The fact that the waters follow the courses of irregular fissures and not of well-defined porous beds is conclusively demonstrated by the different results obtained by borings put down in the immediate vicinity of one another. For instance, on the property of Messrs. William Dow & Co., the C. P. R. workshops at Hochelaga, the Excelsior Wollen Mills, and elsewhere; wells affording an abundant supply of water are situated in the immediate vicinity of equally deep borings which supply little or no water. The Laurie Engine Company, having bored a hole to the depth of 700 feet without striking water, in another boring a few feet away obtained water at a depth of 300 feet. The character also of the water obtained from wells in the immediate vicinity of one another differs greatly, as well as the height to which the waters rise within the boring. A striking instance of this is afforded by the three wells at St. Laurent which were put down by the College, the Convent and Mr. Cousineau. In these, the water was struck at a depth of 487, 250 and 128 feet, respectively. The water in the first stands at thirteen feet and is soft and slightly sulphurous, that in the second rises to the surface and is very hard, while in the third well the water rises thirteen feet above the surface and is of moderate hardness.

In some cases the fissures can be distinctly recognized in boring the well, the drill dropping into an open space, this open space being in some instances empty but in other cases carrying an abundant supply of water. In the case, for example, of one well put down by the Gould Cold Storage Co., as has been mentioned, the boring tool became so firmly

jammed in a transverse fissure that the hole had to be abandoned.

In the wells put down by Mr. J. N. Drummond of Petite Côte, and by the Montreal Milling Co. at Outremont, "breccia" and "honeycomb," respectively, were stated to form the water-bearing rock. These probably represent impure beds or fissures imperfectly cleaned out, the more soluble material having been abstracted. In the case of the Laurentian Baths well on Craig Street and Dr. Craik's well at Petite Côte, the water rises from shaly layers which probably represent the insoluble residue of a bed of argillaceous limestone, into which the water moving through the fissures had here found its way.

The course of the underground waters is also without doubt in many places rendered still more irregular by the dikes and sheets of impervious igneous rock which cut through the stratified rocks in all directions.

An inspection of the Tabular Statement of the wells will show that at a very moderate estimate the wells already bored would yield 2,500,000 gallons per diem; which is almost exactly one-tenth of the daily average amount of water pumped by the Montreal Water Works for the use of the city.

The waters obtained differ greatly in character. Very many of them are soft waters of excellent quality. Others again are hard, while a few are sulphurous or highly saline. As has been shown, it is impossible to predict what the character of the water obtained at any point will be, if any be obtained, for waters of very diverse characters are pumped from wells situated in the immediate vicinity of each other, or, indeed, may be obtained from the same well, as in the case of number 78.

The source of the underground water is in all probability the higher portion of the plains along the flank of the Laurentian country in the northwestern part of the geological map-sheet. It is scarcely likely that very much of it is derived from the Laurentian country itself, although there is reason to believe that some of it may be. Most of it probably passed underground into the palaeozoic strata along the flank of the

Laurentian plateau. Here the rain water would sink into the soil which almost everywhere mantles the underlying rocks, and, passing down to the surface of these rocks, would flow along it until cracks or fissures were met with, down which it would pass. An abundant supply of water is actually obtained in many places in this district by driving pipes down into the lower portions of the drift which here constitutes the soil, and thus tapping the supplies of water passing over the surface of the underlying rock. The palaeozoic plain along the foot of the Laurentian plateau may be taken as having an average elevation of about 300 feet above sea level, while the surface of the Island of Montreal is much lower. The underground waters thus move to the south under considerable head or pressure, and when the channels through which they pass are tapped by borings in the vicinity of Montreal the water rises by virtue of this pressure, in a very few cases actually reaching the surface, but in the other cases remaining at different distances below it. In only five wells on the Island does the water rise more than 200 feet above sea level; the wells in question being the Park well, the wells of Messrs. Nantel and Goyer at Côte des Neiges (where the water rises 340 feet above sea level), and the wells of Messrs. Drummond and Stewart at Petite Côte, where the water rises 225 feet above sea level. In only eleven of the wells does the water rise to the surface, and in only six does it overflow. These latter are the wells at the Turkish Baths, Laurentian Baths, Montreal Cold Storage Co., M. Cousineau, Messrs. Viau Frere, and Messrs. Charles Gurd & Co. It will be noticed that the five wells above mentioned, in which the water rises above the 200 feet level, are all situated on the slopes of Mount Royal, and it is doubtful in how far the drainage from the mountain itself affects them.

It is just possible that the Potsdam sandstone which outcrops immediately along the edge of the Laurentian plateau carries water which subsequently rises through fissures in the limestone, and it would be very interesting if a boring sufficiently deep to tap the Potsdam sandstone were made on the

Island of Montreal, in order that it might be ascertained whether this formation carries any considerable supply of water. A study of the records of the borings, however, would indicate that the water-bearing channels lie chiefly in the Trenton and Chazy limestones; the deeper wells affording but little water, or water which is very impure.

Upon its source, the kind of rock traversed and its solvent power, the presence of dissolved carbonic acid, etc., depends the character of the water in any particular well. It can be readily understood that water passing through the Potsdam sandstone or the underlying Laurentian rocks and rising in fissures through the overlying strata to the surface would probably be soft. If, on the other hand, the water has traversed the limestone or dolomite throughout its entire course, following tortuous channels, a considerable amount of lime salts might be taken into solution and the water might thus become hard or possibly impure from the presence of saline and sulphurous compounds.

In conclusion, it may be asked, as a practical question, what the chances are of obtaining water by boring in the Island of Montreal. As has been shown, it is never possible to predict with certainty that water can be secured by boring at any particular spot, but a simple calculation based on the actual results obtained by the wells (eighty-nine in number) which have up to the present time (January 1, 1904) been put down in this area, shows that the chances of obtaining a large supply of water—that is to say, more than 5,000 gallons per diem—are about 7 to 2. That is to say, water will be obtained in seven out of every nine wells bored; while water of potable quality and in large amount will be secured in rather more than six out of every ten trials or in about two out of every three holes. In some of these, however, the water will be hard.

A second practical conclusion which can be drawn from the results which have been presented in this Report, is that if a boring is put down and water is not obtained by the time a depth of 750 feet has been reached, it is better to abandon

the hole and sink another, rather than to continue boring deeper, even if this second hole has to be put down in the immediate vicinity of the first, since it has been shown that at depths greater than this abundant supplies of good water are rarely obtained, the water (if any be found) being in the great majority of cases small in amount or too impure to be of any value.

DISCUSSION

Mr. Dresser.—I should like to ask Dr. Adams what he considers the source of the mineral constituency, particularly of the salt waters struck in these wells ?

Dr. Adams.—That is a problem on which I cannot undertake to give an opinion. Dr. Hunt examined a great many of the mineral springs of this part of Canada, and, from a great many analyses, he established a number of different classes for these waters. I find that there are four of Dr. Hunt's classes represented in the water of Montreal wells. The saline contents of these waters Dr. Hunt thought represented portions of sea water which was being gradually washed out of the rocks. He thought also that a portion of the saline matter was derived from decomposition set up in the rocks themselves. The waters of the deepest wells rising from the calciferous are apt to be saline or sulphurous.

Mr. Brainerd.—You did not mention the temperature of these waters?

Dr. Adams.—Unfortunately, I have not been able to get records concerning the temperature of the waters, except in a few cases.

Mr. Brainerd.—Then the question of capacity. Do the wells vary much in output? One I know about in town gives 50,000 gallons a day; but I do not know whether this covers a ten or twenty-four hour day. Would 50,000 gallons in ten hours be above the average?

Dr. Adams—I should think 50,000 would be rather large for the average. It might not be in one of the large

Laurentian wells. Some of these Montreal wells, however, have a very much larger capacity than Mr. Brainerd has mentioned. One of the C. P. R. wells at Hochelaga yields 240,000 gallons and another 120,000 gallons per day of twenty-four hours.

Mr. Brainerd—Does one artesian well rob the flow of others near it?

Dr. Adams—When the water is derived from a bed of porous rock, one well robs another when you put down a great many, but where the water runs through cracks and fissures, one well does not rob another, near it, as a rule.

Mr. Burley Smith—In the various wells described have you observed any uniform level at which the sulphurous water is first encountered?

Dr. Adams—There is no uniform level, but the sulphurous waters come from the deeper level.

Mr. Burley Smith—At a certain depth in the wells one strikes fresh water, and further down sulphurous water?

Dr. Adams—Yes, at Maisonneuve, Mr. Viau got good water at 450 feet, but as he was boring for gas he continued to sink, and at 1,090 feet he struck sulphurous water, and now the two waters come up together.

Mr. Smith—Would the inference be that you get sulphurous water at a certain uniform depth in the area referred to?

Dr. Adams—In the lower formation, Mr. Smith.

Mr. Coste—Are there any deep wells on the other side?

Dr. Adams—Yes.

Mr. Coste—Are they sulphurous?

Dr. Adams—Yes.

Mr. Coste—Is there any gas?

Dr. Adams—Yes, but not in any great amount.

Mr. Coste—And sulphur?

Dr. Adams—Yes, sulphuretted hydrogen, dissolved in water.

Mr. Smith—How many feet did you say?

Dr. Adams—1,090 feet, Mr. Smith.

Mr. Smith—Have you any special reason to offer for that?

Dr. Adams—Just that they go through and down to the lower limestone formation.

Mr. Smith—Would there be any co-relation in the height to which the water rises in the different wells?

Dr. Adams—I have not been able to notice any definite relation in the height; on the contrary, they run up to several uneven heights.

Mr. Smith—The inference is if they had not gone so deep, they would have got better water as regards quality, but less in point of quantity.

Dr. Adams—If they do not happen to strike a fissure carrying fresh water by the time they have gone through the chazy, they are apt to encounter saline or sulphurous water. If good water has not been obtained by the time a depth of 750 feet has been reached it is better as a rule to drill another well thirty feet away even, than to continue the boring to greater depths.

Mr. C. H. Taylor—I had something to do with these artesian wells in the city. A well at the depth of 580 feet gave by test seven gallons per minute at the Gould cold storage. Another one they put down to a depth of 1,350 feet, and about sixty feet distance from the first one, gave only nine gallons per minute; while one on the opposite side of the road, owned by Lovell & Christmas, about 100 feet distance further on, at a depth of 680 feet gave forty gallons per minute. At the Excelsior Woollen Mills I made a test to determine the quantity of water; and the first ten days it gave 5,000 gallons per hour continually pumping, after that it only gave 1,800 gallons per hour. When the well lay idle, it would take three or four days to reach its normal condition. At the Lovell & Christmas well it seemed to be a constant flow. Gould's seems to be the same. At the Lovell & Christmas well, every time they stop the pumps and start it up again they always pump muddy water.

Dr. Adams—I have these recorded, and most of this information will be in the report.

Dr. Walker—I would like to know whether any experiments have been made in exploding nitro-glycerine in these bore holes, with a view to increasing the flow by shattering the rocks. This is regularly done in connection with the oil wells in Western Ontario.

Mr. Brainerd—If one used explosives at various levels, the result might be satisfactory. In one place where they were boring for coal, they struck water in such volume that their pumps were not able to cope with it.

Dr. Adams—I expect that was put down in a shaly instead of a compact well rock. Another reason for that would be that in connection with the water there might be an explosion of gas which would throw up a large quantity of water. The water would stop flowing after the gas was exhausted. It would distinctly affect the quantity of the water for the time being.

Mr. Coste—I would like to add a little to this discussion in regard to the first question asked by Mr. Dresser, viz., the source of the salts and of the sulphurous ingredients in the deeper waters. I do not agree at all that this is due to the waters circulating through a certain horizon or formation, viz., the chazy or calciferous, because in a great many other districts on this continent where deep wells have been put down it has always been the case that at shallow depths the water was found to be fresh while further down a very strong saline water was struck which very often was also strongly impregnated with sulphur gas. This is the case not only in Ontario, Pennsylvania, New York, West Virginia and Ohio, but also in many other places on the continent. In all of our gas wells in Welland and Essex, for instance, in every one of them we have to shut off what we call the salt water, and this water is struck either in the Onondaga, the Niagara, the Clinton, the Medina or the Calciferous. In Pennsylvania the salt and sulphur waters are in many horizons of the Devonian or carboniferous formations. There is no doubt in my mind that these chlorides and sulphides come up from below in the shape of vapors and gases and the fact of changes caused by earth-

quakes in the waters of the Montreal wells mentioned by Dr. Adams prove that to a certain extent. When one drills down in every one of the districts I have just mentioned one is liable to get not only strong sulphur and salt waters in any and every one of the formations, but often large quantities of gas and oil. As Dr. Adams has clearly shown, the fresh water goes down through cracks and fissures and in the same way these hydro-carbons, chlorides and sulphur gases and vapors come up also in cracks and fissures; they simply travel in ascending order instead of descending order. It is an undisputable fact that we get these salt and sulphur waters in almost any location in North America, either at any and all depths in strata such as this where water circulates in cracks and fissures, or at certain horizons in porous sandstone or limestone reservoirs where it has stored up from the cracks and fissures traversing these. Dr. Adams has cited Hunt in support of the idea that the salt water might be due to the salt left in the rocks by the old seas, but what about the sulphur gas? It certainly has nothing to do with the old seas. Then again as the water only circulates through cracks and fissures of the rocks it shows that these rocks are not porous, and therefore it would be impossible for the waters to dissolve much salt out of them, even if they were rich in salt; they would only dissolve what little there would be along the walls of the fissures.

NOTES ON CONCRETE.

By R. W. Leonard, C.E., St. Catharines, Ont.

Concrete is so well known that it is unnecessary in a paper intended for the Canadian Mining Institute, to give a definition, or to touch on its history or essential composition, or to give many examples of its wonderful adaptability and great value in a wide range of engineering works.

Cement

This paper will consider concrete made from hydraulic cement only, as we now have on the market such a number of brands of this cement (both native and imported) of such excellent quality and such reasonable price, that in very rare cases will it be advisable to use lime in important engineering structures requiring strength or durability when exposed to the action of water.

Such hydraulic or "Portland" cements are generally manufactured by the grinding together and fusing and subsequent grinding of clay and limestone in proper proportion. The clay may be in the form of shale, and the limestone in the form of marl, and we, therefore, have "Rock Cements" made from shale and limestone or from argillaceous limestones or "Marl Cements" made from marl and clay.

Cement made from blast furnace slag is made extensively in Europe and appears to be highly esteemed.

By careful attention to the chemical constituents and fine grinding, the tensile strength and uniformity of behaviour of these artificial cements have been very greatly improved of recent years, and in these and all other good qualities, I am glad to be in a position to state that several of our Canadian cements are excelled by none in the market.

"Standard Specifications for Portland Cement," prepared by a committee of the C. Soc. C. E., Jan. 1903, requires that:—

"A maximum residue of 10% shall be retained on a sieve of 10,000 meshes per square inch, and the whole of the cement shall pass through a sieve of 2,500 meshes to the square inch.

"The specific gravity shall be between 3.09 and 3.25 for cement not over two months old."

Tensile strengths in pounds per square inch are required as follows:

	Tensile Strengths.			Compressive Strengths.
	3 days.	7 days.	28 days.	28 days.
Neat	250	400	500	....
3 Standard Sand to 1 Cement	....	125	200	2,000 lbs.

The above specification is lenient and it is common to specify a fineness such that at least 95% shall pass through a 100 mesh sieve, and that neat cement shall bear a tensile strain per square. inch at 3 days of 300 lbs.; 7 days, 450 lbs.; 28 days, 600 lbs.

The writer has been offered Canadian cement at market price guaranteed 95% to pass through a 100 mesh sieve, and about 80% to pass through a 200 mesh sieve, to test neat, in 2 days, 250 lbs.; 7 days, 800 lbs.; 28 days, 900 lbs.; and 3 to 1:—7 days, 250 lbs.; 28 days, 350 lbs.; 3 months, 400 lbs.

The time of setting generally desirable is for initial set from one to two hours, final set about 5 to 8 hours.

Perhaps the most important quality of cement (that of "soundness") is tested by making neat cement mortar pats about 3 inches diameter and ¼ inch thick in centre with thin edges on clean pieces of glass. These pats are allowed to set under a damp cloth and are then exposed to warm vapour—about 130 degrees F.—in a covered vessel for several hours and afterwards boiled in water for several hours longer. These pats on removal from the water should not be curled up nor distorted nor show cracks on the surface. When separated from the glass the pats should, when broken, break with a sharp, crisp ring and show a good measure of strength.

The above boiling test for soundness is generally considered severe, and probably some good cements will not stand successfully the boiling test, which is not definitely specified by the com-

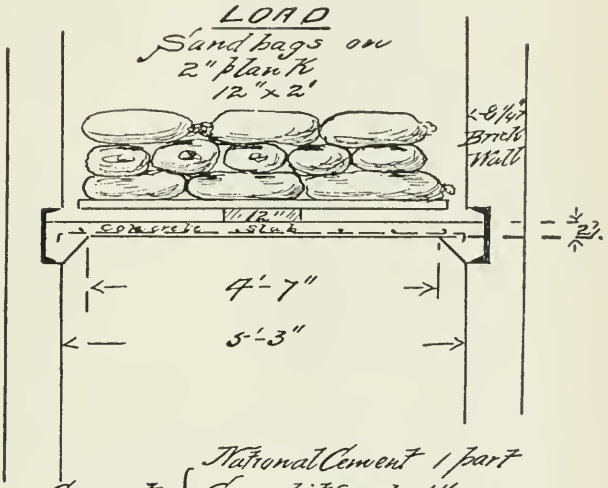
mittee of the C. Soc. C. E. At the same time most manufacturers in Canada sell their cement subject to this test and is is believed that an unsound cement will fail under this test.

The test for soundness is given more in detail than some of the other tests because, for small or not very important works, it is not practicable to start a complete laboratory for testing, and in such cases, the engineer is perfectly safe if his cement stands the test for soundness, feels fine like flour when rubbed between the fingers, and sets in a reasonable time. For all extensive or important works a testing laboratory is necessary and should be established under charge of a competent engineer to test all concrete materials, to determine not only the quality of the cement but the amount of clay in the sand, gravel and broken stone, and the most economical proportions of these materials to use in the different portions of the works.

Before leaving the subject of cement, it may be noted that though we know so much about the chemistry of cement, there are many problems yet unsolved, and among them is the effect of varying proportions of magnesia which is not yet satisfactorily determined, though generally we specify that cement shall not contain over 3% of magnesia.

SAND

Sand to be used with cement is generally specified to be sharp, clean and coarse. Standard sand used for testing purposes is quartz crushed to pass through a 20-mesh screen and be retained on a 30-mesh screen. Experiments made by E. C. Clarke, of the Boston Drainage Works, show that the finer the sand the less the strength. Experiment made by O. B. Suhr, resident engineer of the Niagara Construction Co., of Niagara Falls, Ont., indicate that the best results were obtained with a sand containing all sizes of particles in proportions to make a dense mixture, and, therefore, pit sand briquettes gave higher tensile tests than crushed granite sand, and crushed limestone—to pass through a ⅛ inch. mesh—used as sand, gave about the same tensile strengths as pit sand.



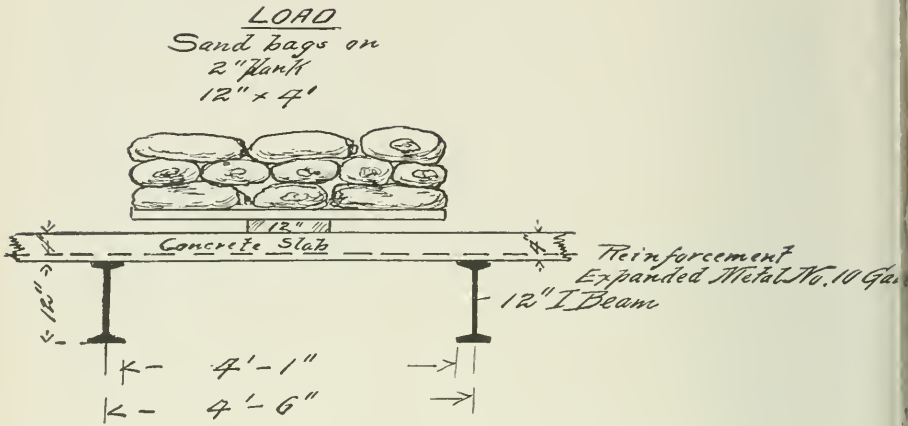
Reinforcement-
3/16" ø Steel Rods
laid 6" C. to C. across and
ngthwise of floor and
ed with wire at
intersections

Concrete { National Cement 1 part
Coarse pit Sand 1 1/2 "
Lime Stone 3/4" Mesh 2 1/2 "
& under

TEST. 28 days.

Load	Deflection	Notes.
1,500 lbs	0.002 ft.	
3,620 "	0.006 "	
4,220 "	0.008 "	No Cracks Showing
4,220 "	0.012 "	½ hour later. No " "
000 "	0.006 "	

= 2,110 lbs. per Sq. ft. without sign of failure



Concrete { Atlas Cement 1 part
At Sand 2 "
" Gravel 5 "

TEST 28 days

Load	Deflection	Notes
3,000 lbs	0.001 ft.	
6,000 "	0.004 "	
7,500 "	0.006 "	
10,500 "	0.013 "	
13,250 "	0.014 "	
14,000 "	0.017 "	Showed hair cracks on
0.00 "	0.005 "	under side

= 3,500 " per Sq. Ft.

The results of experiments carried out by the writer during he past season are in accord with these results.

Tests for abrasive strengths carried out by Mr. Suhr, show that cubes of neat cement, crushed granite sand and cement 3 to 1, pit sand and cement 3 to 1, and crushed limestone and cement 3 to 1, showed results advancing in strength in the order named, probably on account of the limestone and cement being of comparatively equal hardness, while the quartz particles in the granite sand broke out leaving the softer cement exposed to the wear.

Captain H. Taylor made experiments with standard sand, beach sand from mouth of Merrimac River and crusher dust with cement 3 to 1, 4 to 1 and 5 to 1. He found the tensile strength of the dust mortar to be about double that of mortar made from standard sand and about 2½ times that from beach sand. In accordance with these results, it was determined to construct the Boston Harbor Works on concrete, using crusher dust for sand.

Clarke found that adding clay gives a much more dense, plastic, water tight paste. Half a part of clay did not seem to weaken mortar materially except in the case of sample blocks exposed to the weather for 2½ years after a week's hardening in water.

Some experiments noted in the *Engineering News* during the past year indicate that a small proportion of clay added to the mortar gives it an increased tensile strength.

From the above it appears that pit sands (rounded and made up of different sized grains) are more desirable than crushed granite or quartz (sharp); that a little clay is probably not detrimental; that coarse sand or crushed stone gives a higher tensile strength than fine sand, and that the rounded pit sand or the crushed limestone gives better results when subjected to abrasion than clean, sharp granite sand.

STONE

Specifications generally require that stone for concrete should be broken to pass a 2 inch ring and screened, and it has

been considered as essential that the edges should be sharp to secure a bond. Now it is common practice to use gravel in place of broken stone, and the superiority of coarse pit sand over crushed quartz indicates that the practice is good. Gravel and sand pumped from river beds or taken from pits is frequently used and mixed directly with cement to form the concrete. Such concrete possesses the advantage of making a more dense mass with less labor than when using broken stone.

General

The above considerations indicate that the old style of specification of 1 to 2 to 4 and 1 to 3 to 5, etc., where each ingredient was specified with rigid exactness, must be modified if we are to secure the best results for the least money. It is obvious that each locality and enterprise where concrete is to be used, offers a separate problem which must be studied in detail by an experienced, competent engineer. It is not difficult to point to the waste of very large sums of money in engineering works—where large masses of concrete of rich proportions have been used—where at least one-fourth the cost per cubic yard might have been saved without the slightest detriment to the work.

The provision of strongly braced, very substantial forms is very necessary where concrete is laid above ground, and—if a smooth face is desired—dressed two-inch lumber should be used, the face concrete put in wet and carefully worked with a spade against the form to get the mortar face homogeneous. It is difficult to brace forms to allow of a greater height than three or four feet of concrete being laid in one day, and the surface of this lift should be well wetted down next morning and covered with a little mortar before depositing the regular mixture.

Concrete in Mining

Concrete is especially applicable to mining on account of the facility of handling and placing it underground in confined spaces for such purposes as tunnel linings, supporting columns, machinery foundations, shaft linings, dams, stoppings, and fire-proof structures above and below ground.

The re-enforcing of concrete with steel, which has recently come into such general use, where lightness and strength are desired in a permanent structure, makes it practicable to use concrete for many purposes for which a short time ago lumber would be exclusively used. The expense of a building constructed of a steel or timber frame with concrete floors, walls and roofs is in most localities very moderate considering the advantages in durability and fire risks secured.

There are many systems of re-enforcing concrete advertised extensively, and they probably all possess considerable merit either in strength or convenience in use; but it is questionable if plain, round steel bars, properly proportioned and located to take the strains, are not as good, considering the cost.

Experiments show that clean, straight, round steel bars have an adhesive strength when embedded in cement mortar of about 250 lbs. per square inch of surface; that steel or iron bars are perfectly preserved from corrosion when embedded in good wet laid cement concrete, and that rust—unless in form of scale—does not damage the metal for such use.

The diagrams showing tests of floors constructed by the writer of re-enforced concrete will give the average engineer a more definite idea of the great strength of such material:

By comparing the loads carried by the two floors per square foot, the span, and thickness of the floors tested, it will be seen that—though the concrete is richer in the thinner floor—it compares very favorably with the more expensive one.

During the past eighteen months the writer has constructed the entire hydraulic works necessary for the development of about 35,000 horse power for the Hamilton Cataract Power, Light & Traction Co., near St. Catharines, using about 12,000 cubic yards of concrete for weirs, dams, bridges, abutments, retaining walls, culverts, piers, foundations for buildings and machinery, draft tubes for turbines, floors carried on columns and bearing heavy weights, walls and roofs of buildings (re-enforced), etc. Immediately previous to this he constructed thirty-five miles of railway, using about ten thousand cubic yards of concrete in bridge abutments, piers, arch culverts and box cul-

verts, etc., and in neither of these important works has a cut stone been used—or any stone whatever—except as a portion of the concrete matrix.

A great advantage of using concrete is that with competent supervision unskilled workmen can very quickly be trained to do the work, and the employer is thus freed from the difficulty and expense of using skilled union labor, which has probably been a very active agent in extending the uses of this most valuable building material until it has taken the place of stone and brick work to an extent that few realize.

It is a common statement that concrete can not be made water tight. The writer can show an eight inch re-enforced concrete wall (cement, sand and gravel,) which—under a head of seven feet of water—shows a dampness in spots only on the lower side and no precaution was taken to make it water-tight other than good, honest workmanship. He can also show concrete retaining dams that show not even a dampness on the outside when subjected to a head of fifteen feet of water, and has built a three foot concrete wall on an old concrete foundation five feet under water which, when retaining a head of seven feet of water against it, showed a very few small trickles of water leaking through it.

VALUE OF UNDEVELOPED MINING CLAIMS.

By G. R. Mickle, Toronto.

As everyone interested in mining in an undeveloped country is confronted with this question occasionally, the writer hoped to present the subject in such a form that it would be capable of analysis and provoke a useful discussion. Generally the value of an undeveloped claim is regarded as something so uncertain that it evades all calculation and the price is fixed by the whim of the owner. We see, however, that while nothing is more uncertain than human life as far as any individual is concerned, yet one of the safest businesses that exist is based on the chance of life, the aggregate amount of capital invested in life insurance in Canadian companies alone being about $80,000,000, with no failures recorded.

Is it possible to apply to the question before us the same principles that govern life insurance?

It is evident in the first place that as there is no certainty that any given claim will ultimately prove capable of being worked at a profit, the correct expression would be "the value of the chance that it may become a profitable mine or working under development." In order to make the question more definite, it will be assumed that it is desired to estimate the probable value the claim will have provided the development work has given satisfactory results and the claim has become a mine or working with sufficient profits assured to justify undertaking the continuous and systematic extraction of the mineral product. It will be taken for granted, moreover, that in the case of deposits extending to the surface, the soil, etc., has been removed.

The value of the claim would depend on the following factors, viz.—

1. Probable value it would have provided the development work is successful. Call this A.

2. Chance that development work will be successful. Call this B.

3. Probable cost of the development work. Let this be C.

4. Interest on money spent on work. Call this D.

The "present value" would be

$$A \times B - (C + D).$$

If all the estimates are correct, a purchase of a large number of claims at the various amounts indicated by above calculations would leave no profit for the buyer, the price paid should therefore be less by an amount dependent on the degree of risk and expense involved in development.

So far, it seems to the writer, no exception can be taken to the argument, it is when an attempt is made to allot definite figures that differences of opinion will arise and the very highest skill and judgment will be required.

In entirely new districts, where no information can be had from work on similar claims, all the factors entering into the calculation will be most difficult to estimate, it is here unfortunately that we are most interested, where the periods of excitement arise and the times of active buying and selling.

The first factor in the calculation, viz., the probable value the claim would have provided the development work is successful, could possibly be approximated by estimating probable amount of mineral product that would be exposed on working, and the profit on extraction. This would involve of course an estimate of cost of bringing the product to the surface, whatever treatment is necessary to prepare the product for market the percentage of loss which would be incurred and all expenses incident to marketing. Except for the first discoveries in some new district, the coefficient expressing the reliability of the estimate would probably vary from say, $\frac{1}{3}$ to 3, that is, the estimate might be a figure three times the actual value or only one-third.

Coming to the second factor—the chance that the development work will be successful—we are met with the greatest difficulty, a difficulty that will, in many cases, in the absence of similar claims

in the same district that have been developed, be altogether baffling. In some unique instances the chance that development work would be successful is a certainty, and the numerical expression for the chance would therefore be unity. This can apply only to districts where there has been work already done on a great number of claims; as an example of one of these happy cases we have the Shansi coal fields of China. Speaking of an area of more than 200 miles by 30, Mr. Kurita says, "This whole area is one unbroken coal field with workable coal from 25 to 50 ft. in thickness. Every village town and hamlet has its own coal mine or mines." (*Eng. and Min Jour.,* Vol. LXV., p. 491.)† As an instance, in metal mining, where the chance approaches unity, we have the unbroken sketches of heavily producing properties along the main reef series in the Transvaal. From unity, the numerical expression for the chance can vary to some indefinitely small fraction, dependent mainly on termination of deposit or irregularities in size or value or both. It is unnecessary to mention cases of this kind, they will occur to everyone. New discoveries as before, are the most difficult to estimate, and unless the natural conditions are such that there is an actual exposure of a large amount of some product of value, few engineers would venture to express this chance by a definite fraction. In more favorable cases, the coefficient expressing the probable accuracy of estimate of this factor, would perhaps vary from, say, 2 to $\frac{1}{10}$ or even more.

The third factor should be capable of a closer estimate, and as it will be small compared with A, an error here will not affect the result seriously, as extremes we should probably have an amount varying from about a third to one-hundredth of A. D, the fourth factor, can almost be disregarded, even in cases where the development work is very heavy and takes a long time the amount will most likely not exceed 5% of A.

Returning to our equation for expressing the present value of the claim, calling the present value y, we have $y=AB-(C+D)$. As A and B, particularly, vary within wide

† See also Trans. Am. Inst. Min. Eng., Vol. 30, p. 261, for description

limits in new districts, it follows that the equation cannot be solved in such cases, unless B can be approximated in some way. How the value of y is affected by B will be seen more readily from a graphical representation. See Fig. 1. Draw axes of y and A at right angles to one another and make A equal 100.

Then to find line expressing equation, $y=AB-(C+D)$, assume different values for B leaving A fixed. If $B=1$, for instance, or the chance is a certainty, then $y=A-(C+D)$; when $y=O$, or the line crosses axis of A, $A=C+D$. Now, C+D we can assume as 15% of A, find this point along axis of A and call it a'. Also when $A=O$, or the line crosses axis of y, then $y=-(C+D)$. Measure this in a negative direction, call it y', then the line expressing equation $y=A-(C+D)$ which is a straight line as no higher powers are involved, passes through these two points y' and a'. Produce the line in a positive direction, at the point A draw a line parallel to axis of y in positive direction to intersect line $y=A-(C+D)$, then this line will represent the value of y. In this case, of course, it equals 85% of A. A purchaser would probably be justified in paying some amount less than 85% of A, possibly, say, 70%, as there is no risk involved.

Similarly if $B=\frac{1}{2}$ (Fig. 2)
$y=\frac{1}{2}A-(C+D)$
when $y=O$
$\frac{1}{2}A=C+D$ or $A=2(C+D)$.

This point gives a" on axis of A, also as before when $A=O$, $y=-(C+D)$, measure C+D in negative direction. Through these two points, a" and y', draw a straight line and find as before intersection of this line and line through A parallel to y. It will in this case equal 35% of A. Here the actual present value is only 35% of A, with a risk of 1 in 2, it does not seem reasonable to pay more than 10 or 15% of A for such a claim. If B, or chance of success, equals $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, 1-7, etc., and lines expressing equations $y=\frac{1}{3}A-(C+D)$, etc., be drawn it will be noticed that the value drops down rapidly, being respectively 18, 10, 5, 1.6 and —0.8% of A. With B or chance of success equal $\frac{1}{3}$ and the

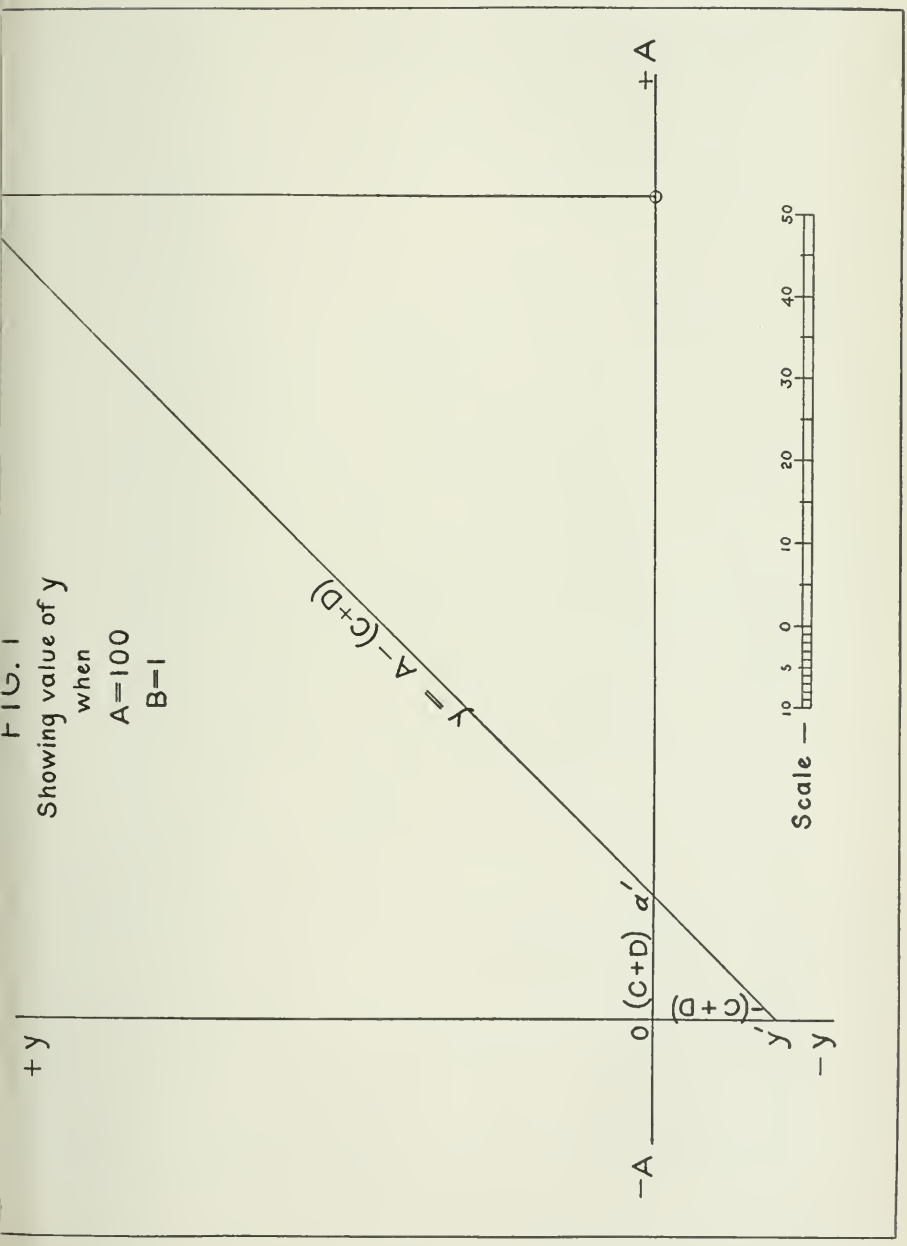


FIG. 1
Showing value of y
when
A=100
B=1
+y
−y
+A
−A
0
(C+D)
a′
y′
(C+D)
y = A − (C+D)
Scale —
10 5 0 10 20 30 40 50

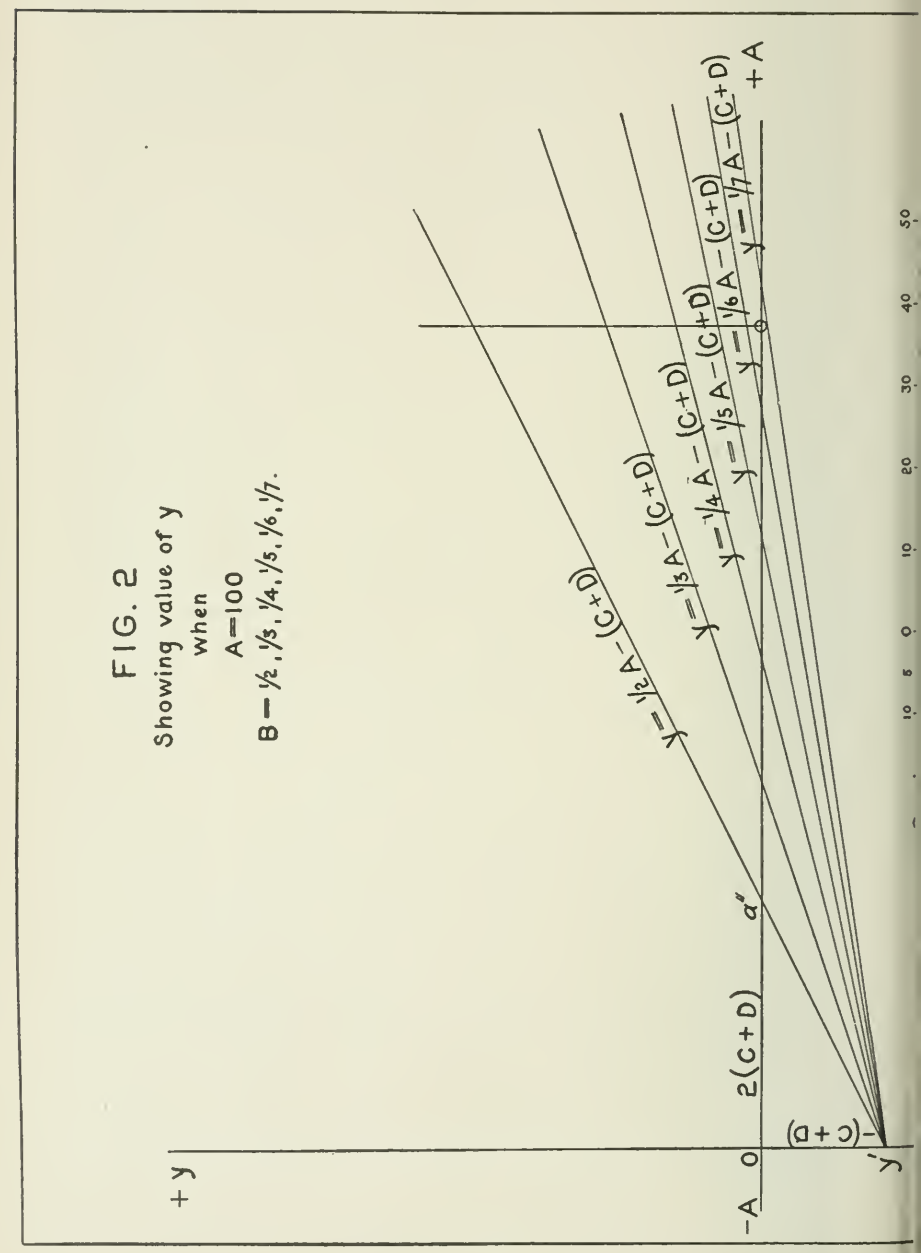


FIG. 2
Showing value of y
when
A=100
B = ½, ⅓, ¼, ⅕, ⅙, ⅐.

present value only 18% of A, nothing more than an insignificant percentage of A should be paid for the claim on an outright purchase although it would be worth developing. The others are certainly worth no cash and probably not even the expense of development. It appears to the writer that this is why even the best managed companies which set out to purchase and develop a large number of claims so seldom make a profit on their operations as a whole.

A few modifications, of course, suggest themselves, for instance, in the case of very rich ores, there might be considerable value in ore already exposed by natural agencies, in which case the value of the claim would be estimated profit on this ore plus the value as calculated as above. Moreover, only risks inherent to mineral deposits as such have been taken into account, the variations in value of claims due to fluctuations in the price of the product of the claim, would form another disturbing factor, further upsetting the calculations.

It is evident that the conditions which make life insurance such a safe business, viz., the possibility of having a large number of cases on which to base calculations of chance, and the elimination of the chance in an individual case by accepting a very large number of risks, are impossible in mining; the first, because statistics bearing on the chance are only obtainable in a district that has been extensively worked in many places, the time when this information would have been of most value is then long past. Owing to the amount of money involved it is impossible for any ordinary individual or company to invest in a very large number of claims.

If the writer is correct in his statement of the case, it follows that the prices commonly asked for undeveloped claims in this country, running frequently into the tens and sometimes even hundreds of thousands of dollars, are too high and purchases should be made on long options, say, one to three years, without cash payments. It is only when there is some means by which the factor B, or the chance that the claim will develop into something of value, can be intelligently approximated, that we can calculate even roughly the value of an undeveloped mining claim.

DISCUSSION.

The President.—Prof. Mickle has demonstrated mathematically in his paper a matter that is very interesting, as bearing on mining laws. He has shown us the unwisdom of paying for a mineral claim in most cases, without the chances first afforded of working the property to prove its value, but so long as our mining laws remain as they are, it is not easy to follow out this advice. In Ontario, for example, where we have so large an area of so-called mineral lands, I have shown that the Government has disposed of four hundred thousand acres, and yet less than one per cent. of this area has been actually worked. It is impossible that our mineral resources should be properly exploited under these conditions.

Dr. Goodwin.—I have been much interested in Prof. Mickle's very clear demonstration of the fact that owners of mining claims should come down a little in the prices they ask for their properties, and I am quite sure that the publication of this paper will have some influence. I should hope that it would have a still wider influence if it were not for the difficulty of convincing a great many people by demonstrations, however clear those demonstrations may be.

Mr. Garde.—Prof. Mickle has done us a service by pointing out that it should be possible to secure mineral property under option, provided the prospective purchaser was able to show that he was prepared to spend money in the development of it, and I quite agree with him that this is the only way in which to operate in our new mining districts. I only regret that some of my prospector friends in British Columbia cannot be brought to take this view of the matter.

THE ELECTRIC SMELTING OF ZINC ORES.

By Frederick T. Snyder, Oak Park, Ill.

The present method of smelting on a lead basis ores containing gold and silver, consists in fusing in a blast furnace a mixture of ores containing approximately 30 per cent. silica, 20 per cent. of the oxides of iron and manganese taken together, 25 per cent. of alkaline earths, 5 per cent. of sulphur, 5 per cent. of zinc and 10 per cent. of lead. A modern furnace will handle 200 tons of such a mixture per day. The product of smelting this daily charge will be about 170 tons of slag, 6 tons of matte to be re-smelted, and 19 tons of lead, the lead carrying approximately all of the gold and silver which was in the various elements of the charge.

The zinc in the charge, amounting to 10 tons per day, does not appear in the product, it having been forced into the slag and thrown away. In general, at the average smelting plant, it is a commercial requirement that the furnaces should smelt and waste as much zinc in the slag as is technically practical, the reason being that lead and precious metals can be purchased more cheaply when contained in a zinc ore than when occurring in other forms of ore. The practical limit to the amount of zinc which can be slagged off is about ten per cent. If more zinc than this is put into the charge a portion of it will be reduced to the condition of metallic zinc, which will be volatile at the furnace temperature. This volatile metallic zinc, meeting the oxygen of the blast, is oxidized to zinc oxide. Such zinc oxide being infusible, accumulates in the furnace, clogs it up, and stops the process of smelting. If it were not for the oxygen of the blast, both metallic lead and metallic zinc would be produced at the same time. If removed from the furnace in a metallic form, the value of the zinc which might be recovered from an average furnace charge would about equal half the value of the lead pro-

duced at the same time, and would exceed per year the first cost of the smelting plant.

The heat needed to smelt such a charge is usually obtained by the combustion of coke inside of the furnace. A blast is forced into the furnace to furnish the oxygen required for this combustion. If this coke were burned outside the furnace, and the resulting heat separated from the gaseous products of combustion and transferred within the furnace, the volatilized zinc would not meet the blast, and escaping oxydization, might be condensed and removed in metallic form. Electricity forms a possible way of doing this. If the coke be burned under a boiler, most of the heat of its combustion will be transferred to steam. A part of the energy of this steam can be changed through the usual medium of a steam engine and dynamo into electricity. Almost all of the energy of this electricity can be delivered into the furnace as heat. Another way of doing it would be to burn the coke in a gas producer and use the resulting gas to drive a gas-engine dynamo combination. In such a way more of the total energy in the coke would reach the furnace.

In average modern practice, 250 pounds of coke are burned per ton of charge. Ten pounds of this coke are required chemically inside the furnace for the reduction of lead. No blast is required for the burning of this part of the coke, as the oxygen is furnished by the lead oxide. Of the balance of 240 pounds, part would be saved in burning the fuel outside the furnace. To burn this amount of carbon inside the furnace requires the introduction of 2,700 pounds of air. To heat this air from an average atmospheric temperature to 400 degrees F., at which gases escape from the furnace top, requires the combustion of 19 pounds of coke as burned inside the furnace. When coke is burned inside a furnace, the combustion is not complete, and the gases as they issue at the top carry off an amount of chemical energy per ton of charge equivalent to the combustion of 76 pounds of coke under present furnace conditions. If these losses be deducted there remains 145 pounds of coke whose heat of combustion

would have to be put into the furnace electrically to enable a furnace to run on the present basis without blast.

Under conditions of good average modern practice, 70 per cent. of the heat in fuel burned under a boiler will be transferred to the steam; 17 per cent. of the heat energy in the steam could become mechanical energy in a steam engine, and 90 per cent .of this engine power can be delivered from a dynamo as electricity. Of the energy in this electricity, 90 per cent. will become heat again inside the furnace. As the total of this cycle, some 10 per cent. of the heat energy of the fuel would be delivered into the furnace, freed from all gaseous products of combustion. If a gas producer and gas engine dynamo system be used, some 15 per cent. of the total heat in the fuel will reach the inside of the furnace. With such a gas producer, gas engine dynamo plant there would have to be consumed in the gas producer 970 pounds of fuel to put into the furnace electrically the same amount of heat that would be obtained by burning 240 pounds of coke inside the furnace by means of a blast. The fuel used in such a gas producer might be bituminous coal or wood. In practice, some forty-five pounds of fuel are consumed, per ton of charge smelted, in producing the blast; this fuel might be applied to the production of electricity, leaving 925 pounds of fuel to be supplied in place of the 240 pounds of coke, if the furnace was to be run without blast and produce the present products.

If the zinc is to be condensed and saved, in whole or in part, other heat items are involved. Under present conditions, the zinc, per ton of charge, carries into the slag, in the form of zinc oxide, the sensible heat equivalent of 11 pounds of fuel. To reduce this zinc oxide to metallic zinc would absorb an amount of heat equal to the complete combustion of 16 pounds of fuel. This metallic zinc would be volatile at the furnace temperature. If it were all removed and condensed, it would carry away with it the possible heat of combustion of 3 pounds of fuel. The reduction of the 100 pounds of zinc in a ton of charge would produce 43 pounds of carbon monoxide. This carbon

monoxide from the zinc would carry away as sensible heat the equivalent of burning 2 pounds of fuel. As a net result, to save the zinc in such a way would require in addition the combustion energy of 10 pounds of fuel for each 100 pounds of zinc. When zinc is saved in this way there is required a further amount of heat to replace the potential energy carried out of the furnace by the carbon monoxide from the reduction of the lead, as CO_2 could not be formed. This would be equal to the heat energy of about 3 pounds of fuel for each 200 pounds of lead in the charge.

If two-thirds of the zinc in a standard charge were saved, the extra heat requirement per ton of charge would be the total heat of combustion of 10 pounds of fuel, and this might be obtained electrically by burning 67 pounds of fuel in a gas producer. Adding these additional fuel requirements to the 925 pounds of fuel required to eliminate the blast from the present process, makes a total of 992 pounds of bituminous coal that would be required in place of 240 pounds of coke to recover 66 pounds of metallic zinc. If the original charge had contained 20 per cent. of zinc and 10 per cent. of lead there would be required in the gas producer 1,120 pounds of bituminous coal to recover 260 pounds of zinc, and at least 240 pounds of coke of the present process would be eliminated.

If water power is available, the gas producer and gas engine might be replaced by a water-wheel. With a well designed installation, under average conditions, there might be realized in mechanical power on the water-wheel 75 per cent. of the power of the water. Of this mechanical energy, 90 per cent. would be delivered by the dynamo as electricity, and 90 per cent. of the energy of this electricity would become heat in the furnace. Saving 66 pounds of zinc from a ton of charge carrying 5 per cent. of zinc would require 1,429 horse-power hours in the water, or 650 kilowatt hours of electricity delivered in the furnace. Saving 260 pounds of zinc from a ton of charge carrying 20 per cent. of zinc would require 1,607 horse-power hours in the water, or 731 kilowatt hours of electricity delivered in the furnace.

On the basis of the rating of the water-wheels, the 5 per cent. charge would require a plant of 45 horse-power for each ton of charge capacity per 24 hours. The 20 per cent. charge would require water-wheel capacity of 50 horse-power per ton of charge smelted per 24 hours. On the basis of the rating of engine output, the steam or gas plant capacity required would be practically of the same horse-power as the water-wheels. In each of these cases, the 240 pounds of coke and 45 pounds of coal used in the present process would be eliminated.

CALCULATIONS.

Heat Carried Out of Furnace by Blast.

400 F.....Temp. gases from furnace.
70 F.....Temp. atmospheric air.

Specific heat air constant pressure = .24
Heat per pound air = (400 — 70) .24 = 79.2 B. T. U.
200 ton per day furnace requires 5,000 cu. ft. air per min.

$$\text{Pounds of air per ton ore smelted} = \frac{5000 \times 60 \times 24 \times 75}{200 \times 1000}$$

$$= 2700$$

$$\text{B. T. U. per ton ore smelted} = 2700 \times 79.2$$

$$= 213{,}800 \text{ B. T. U.}$$

$$\text{B. T. U. per lb. coke (2-3 } CO_2 \text{ \& 1-3 CO)} = \frac{214{,}200}{3} + \frac{4200}{3}$$

$$= 10{,}900$$

$$\text{Pounds coke per ton ore smelted} = \frac{213.800}{10900} = 19.6$$

Chemical Energy Lost in Furnace Gases.

Burning to 2-3 CO_2 and 1-3 CO in place of 3-3 CO_2.

Heat given out in burning 1 lb. C to CO_2 = 14,200 B.T.U.

Heat given out in burning 1 lb. C to CO = 4,200 B.T.U.

Heat lost per lb. C by incomplete combustion = 10,000 B.T.U.

$$\text{Heat lost per ton ore smelted} = \frac{250}{3} \times 10{,}000$$

$$= 830{,}000 \text{ B.T.U.}$$

$$\text{Coke equivalent} = \frac{830{,}000}{10{,}900} = 76.1$$

Steam Engine Efficiency

42 B. T. U. per min = 1 H. P.

18 B. T. U. per min. in each lb., 150 lbs. steam per hour.

$$\text{Pounds steam per h.p. hour} = \frac{42}{18} = 2.33 = 100 \text{ p.c. efficiency.}$$

Average practice 14 pounds

$$\text{Average practice efficiency..} = \frac{2.33}{14} = 16.7 \text{ per cent.}$$

$$\text{With 12 pounds efficiency..} = \frac{2.33}{12} = 19.4 \text{ per cent.}$$

Mechanical efficiency engine = 85 per cent.

Total efficiency at 12 pounds = 85 × 19.4 = 16.5 per cent.

Total efficiency at 14 pounds = 85 × 16.7 = 14.2 per cent.

Gas Engine Efficiency.

1 ton coal = 30,000,000 B. T. U.

1 pound coal = 15,000 B. T. U.

1 h.p. hour = 2,545 B. T. U.

$$\text{Theoretical efficiency} = \frac{2{,}545}{15{,}000} = 17 \text{ per cent.}$$

Net efficiency heat ..... $= 17 \times .90 \times .90 = 13.77$
Possible gas engine efficiency ..... $= 26$ per cent.
Possible producer efficiency ..... $= 85$ per cent.
Possible power ..... $= 85 \times 26 \times 85 = 18.8$ per cent.
Electric power ..... $= 18.8 \times 90 \times 90 = 15.2$ per cent.

Fuel Required to Produce Blast.

5,000 cubic feet per minute for 200 tons per day.
48 oz. = 3 pounds pressure of air.

$$\text{Ft. lbs.} = \frac{P_1 .29}{P_2 - 1} \div .4 \; P_2 \; V_2$$

Where P_2 is in lbs. per sq. ft. + V_2 in cu. ft.

Horse-power per cubic ft. free air per minute to 3 lbs. = .025

$$\text{Cubic feet per ton ore} = \frac{5000 \times 60 \times 24}{200} = 36{,}000$$

$$\text{Horse-power hour per ton ore smelted} = \frac{36{,}000 \times 25}{60 \times 1000} = 15$$

$$\text{Cost horse-power hour} = \frac{3600}{360 \times 24} = \$.0042$$

Cost per ton ore smelted ..... $= .0042 \times 15 = \$.063$
Pounds coal per ton ore ..... $= 15 \times 3 = 45$

Sensible Heat in Furnace Gases.

Weight of blast per ton ore ..... = 2,700 lbs.
Weight of coke per ton ore ..... = 250 lbs.
Weight of oxygen in lead ..... = 16 lbs.

Total gases from furnace ..... = 2,966 lbs.
Sensible heat ..... $= 2{,}966 \times 79.2$
$= 235{,}000$ B. T. U.

Heat in Lead from Furnace.

Temperature of lead ..... = 1,000 degrees F.
Weight of lead ..... = 190 pounds
Sp. heat of lead ..... = .04 for fluid lead
Heat fusion lead ..... = 24 B. T. U. per pound

Sp. heat ..... = (1,000 — 100) .04 = 36 B.T.U.
Heat fusion ..... = 24
Total heat ..... = 60 B.T.U.

Heat taken out by lead, per ton = 60 × 190 = 11,400 B.T.U.
200 lbs. lead per ton smelted.
190 lbs. lead per ton saved.

Heat Radiated from Furnace.

Water required in water jackets—

Temperature at entering jacket .... = 60 degrees F.
Temperature at leaving jacket ..... = 200 degrees F.
For furnace, 200 tons required.....= 20 gals. per min.
167 lbs. per min.

Water required for jackets per ton charge =

$$\frac{167 \times 60 \times 24}{200} = 1{,}202 \text{ pounds}$$

Heat absorbed.... = (200 — 60) 1,200 = 168,000 B. T. U.
Other radiation, 25 per cent..... 42,000
210,000 B. T. U.

Campbell shows 5 per cent. total heat in
fuel radiated from iron blast furnace —
5 per cent. of fuel of lead furnace..... = 178,000 B. T. U.

Heat in Slag.

Total heat per ton ore = 250 lbs. coke = 3,560,000 B.T.U.

Sensible heat carried off by furnace gases	=	235,000 B.T.U.
Chemical potential heat in furnace gases	=	830,000
Heat in metallic lead....	=	11,400
Heat radiated from furnace	=	210,000
Total heat other than in slag		1,286,400 B.T.U.
Heat in 1,750 pounds of slag		2,293,600 B.T.U.
Heat per pound of slag		1,300 B.T.U.

Heat fusion slag = 600 B.T.U.

$$\text{Specific heat slag} = \frac{1300 - 600}{2190 - 70} = \frac{700}{2120} = 0.33$$

Heat carried to Slag by Zn.

Zn + O = Zn O

65 + 16 = 81

$$100 \text{ pounds Zn} = \frac{81 \times 100 \text{ Zn O}}{65} = 124.6 \text{ pounds Zn O}$$

Heat = $1{,}300 \times 124.6 = 162{,}000$ B. T. U.

$$\text{Pounds fuel} = \frac{162{,}000}{14{,}200} = 11.4$$

Heat to Reduce ZnO to Zn.

Heat per pound Zn.....	=	2,360 B.T.U.
Per ton charge	=	$100 \times 2{,}360 = 236{,}000$ B.T.U
Equivalent fuel..	=	$\frac{236{,}000}{14{,}200} = 16.6$ pounds

Heat Carried Out by Zinc.

Temperature of escaping Zn ..... = 2,000 degrees F.
Temperature of ore charge ..... = 70 degrees F.
Specific heat Zn (2,000 to 100 F.)..... = .08
Sp. heat per pound Zn.. = (2,000 — 70) .08 = 155 B.T.U.
Heat vaporization per pound Zn ..... = 200 "
Latent heat fusion per pound Zn ..... = 112 "

Total heat per pound Zn ..... 467 "

Heat for 100 pounds Zn = 46,700 B.T.U.

$$= \frac{46{,}700}{14{,}200} \text{ pounds fuel}$$

$$= 3.3$$

Heat in CO from Zn.

Zn + C = Zn + C O
81 12 65 28

Sp. heat per pound C O = (2,000 — 70) .23
= 444 B. T. U.

$$\text{Sp. heat per pound Zinc} = \frac{448 \times 28}{65} = 192 \text{ B. T. U.}$$

$$\text{Sp. heat per ton charge.} = 192 \times 100 = 19{,}200 \text{ B. T. U.}$$

$$\text{Fuel required.....} = \frac{19{,}200}{14{,}200} \text{ lbs.}$$

$$= 1.4 \text{ lbs.}$$

Heat Lost in CO from Lead Reduction

Pounds of carbon per

$$\text{lb. lead .....} = \frac{12}{206} = .058$$

Pounds of carbon per ton ore ..... $= .058 \times 200$
$= 11.6$

Energy from CO_2..... $= 14{,}200$ per lb. C.

Energy from

$$(2\text{-}3\ CO_2\ \&\ 1\text{-}3\ CO) = \frac{2}{3}(14{,}200) \times \frac{1}{3}(4{,}200) = 10{,}900$$

Loss per pound C..... $= 3{,}300$ B. T. U.

Loss per pound lead... $= 3{,}300 \times .058 = 193$ B. T. U.

Loss per ton ore..... $= 193 \times 200 = 38{,}600$ B. T. U.

Fuel equivalent..... $= \frac{38{,}600}{14{,}200} = 2.72$ lbs.

20 Per Cent. Zinc in Charge.

20 per cent. Zn = 400 lbs. per ton charge.

2-3 of 400 = 267 lbs. of Zinc saved.

$$\text{Fuel} = \frac{267}{100} \times 10 + 3 = 26.7 + 3 = 29.7 \text{ lbs.}$$

$$\text{Would require in gas producer } \frac{29.7 \times 100}{15} = 197 \text{ lbs.}$$

Total required = 925 + 197 = 1,122 lbs.

Electricity Required.

145 pounds C to run present process.

5 per cent Zn.

$$(16 - 11 + 3 + 2) \times \frac{2}{3} + 3 = 10 \text{ pounds C.}$$

Total energy = (145 + 10) 14,200 = 2,210,000 B. T. U.

$$\text{Kilowatt hours} = \frac{2{,}210{,}000}{3{,}412} = 650 \text{ K. W. H.}$$

20 per cent. Zn.

$$(16 - 11 + 3 + 2)\frac{4 \times 2}{3} + 3 = 29.7 \text{ pounds.}$$

Total energy $= (145 + 29.7)\ 14{,}200 = 2{,}490{,}000$ B.T.U.

$$\text{Kilowatt hours} = \frac{2{,}490{,}000}{3{,}412} = 731 \text{ K. W. H.}$$

Empirical formula for charge with 10 per cent Pb.
Kilowatt hours $= 623 + 5.4$ percentage of zinc in charge.

Water Power Required.

Water-wheel efficiency ..... = 75 per cent.
Dynamo efficiency ..... = 90 per cent.
Line efficiency ..... = 90 per cent.
Net efficiency $= 75 \times 90 \times 90 = 60.8$ per cent.
With 5 per cent. Zn.

$$\text{H. P. hours} = \frac{650}{.746 \times .61} = 1429$$

With 20 per cent. Zn.

$$\text{H. P. hours} = \frac{731}{.746 \times .61} = 1607$$

$$\text{H. P. plant (5 per cent. charge)} = \frac{1429 \times .72}{24} = 44.7 \text{ H. P.}$$

$$\text{H. P. plant (20 per cent. charge)} = \frac{1607 \times .75}{24} = 50.2 \text{ H. P.}$$

Engine Capacity Required.

Line efficiency = 90 per cent.
Dynamo efficiency = 90 per cent.
Combined efficiency = 81 per cent.

Engine capacity

$$(5 \text{ per cent. basis}) = \frac{650}{.746 \times 81 \times 24} = 44.7 \text{ H. P.}$$

Engine capacity

$$(20 \text{ per cent. basis}) = \frac{731}{.746 \times .81 \times 24} = 50.2 \text{ H. P.}$$

ABSTRACT OF AN ADDRESS ON ELECTRIC SMELTING.

By Dr. Eugene Haanel, Ottawa, Ont.

The iron and steel industry is the foundation of all other industries. To develop the former furnishes the means and incentive for the development of the latter. A country which requires to import its iron, the raw material for all industrial progress, is severely handicapped in the race for commercial success. It is only when a country is able to manufacture commodities beyond its need that exportation and expansion of trade become possible.

During the years 1903-1904 (Trade and Navigation Report) Canada imported:

Pig iron, steel ingots, ferros, scrap, etc	$1,727,867
Rails, bars and other manufactured iron and steel	12,172,082
Sheet iron and plates	5,223,250
Wires	2,216,413
Hardware	4,593,226
Agricultural and miscellaneous machinery	17,178,761
Total	$43,111,599
To ascertain sale value add 25%	10,777,899
	$53,889,498

These figures show to what extent we are at present dependent upon outside sources for iron in the crude and manufactured state. The influx of settlers requiring tools and machinery, the building of new railroads, the displacement of wood by steel in modern architecture, the multiplication of established and the inauguration of new industries, will in the near future rapidly increase above the present demand the annual quantity of iron and steel required for home consumption. To stimulate and encourage the production of iron and steel from our abundant

sources of raw material the Government has offered generous bounties on pig and rails produced in Canada and placed an import duty on articles manufactured from iron and steel. Regarding the distribution of the raw material for the production of pig, the conditions of the country are, however, such that the necessary coking coal for blast furnace work is found only at the extreme east and west, while the large Provinces of Ontario and Quebec, possessing numerous and extensive deposits of iron ore are without coal deposits. If these deposits are to be utilized in the production of pig by the present methods of smelting, either coke must be brought to blast furnaces erected in the vicinity of these deposits, or the ore of these Provinces must be transported to blast furnaces erected near an abundant coal supply. In either case the transportation costs render such a course uneconomic. Unless some other method of smelting, in which some other source of energy than that resulting from the combustion of carbon in blast furnaces, can be proven to be practical and economic, the extensive ore deposits of these Provinces will remain to a large extent undeveloped, and regions which might otherwise be made to teem with an industrial population will remain waste areas for many years to come.

The necessity of profitably employing the electric plants erected in different parts on the Continent, especially in France, for the production of carbide, which had to be closed down as unprofitable on account of over-production, furnished the incentive to invent methods for applying electric energy: first, to the production of the different ferros and subsequently to the production of pig and steel.

In the solution of the problem of applying electric energy to the extraction of metals from their ores, Captain Stassano in Italy, and Héroult and Keller in France, have rendered conspicuous service. The description of the experiments made by them and the results obtained attracted wide attention and were eagerly discussed in the scientific press, for it was at once seen that if by the electric process pig could be economically produced, such countries as Brazil, Chile, Sweden, Norway, Finland and our own two Provinces of Ontario and Quebec, all rich in iron

ore deposits and the necessary fluxes and possessing extensive water powers, but lacking coal, would be able to render themselves independent of outside sources by employing the electro-thermic process for the manufacture of their iron and steel.

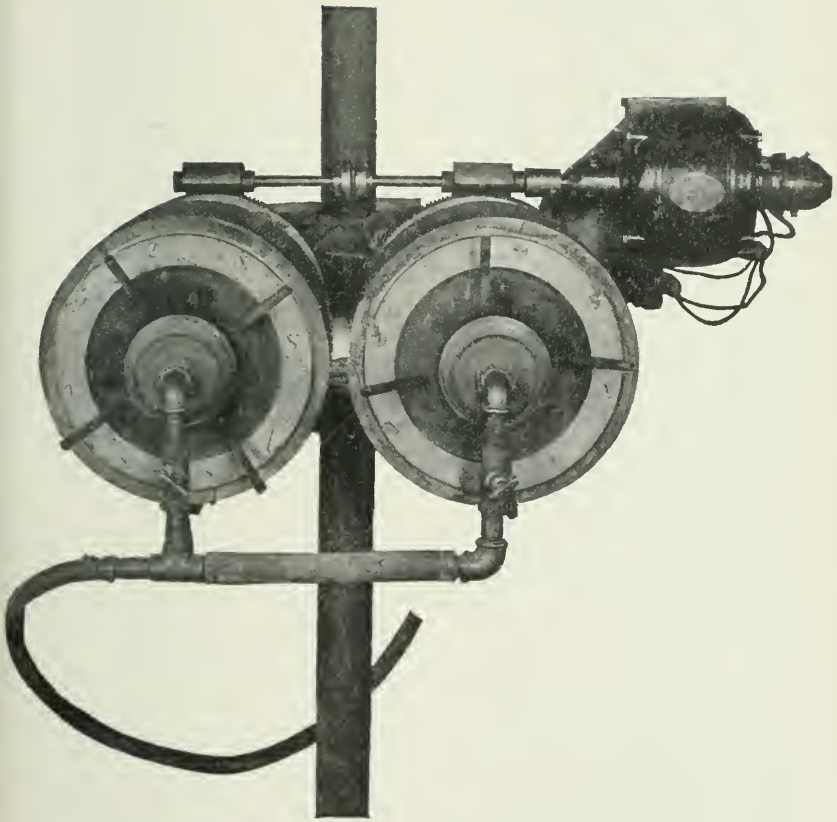
It was with a view of ascertaining the feasibility of introducing electric smelting into Canada that the Honourable the Minister of the Interior appointed two separate Commissions to investigate this subject.

For a number of years the Ruthenburg process of electric smelting of magnetite had attracted attention. Papers on the subject were read by the inventor of the process in the meetings of the Electrochemical Society, were seriously discussed by the members of the Society and published in their Transactions, which gave to this process a quasi scientific sanction. No examination had been made of the process by any competent authority, and whatever had been published so far had been published on the statement of the inventor of the process. It seemed, therefore, desirable that the claims of the inventor, which were rather startling, regarding the efficiency of his process should be investigated by a trial run, and a Commission was appointed on the 2nd July, 1903, by the Honourable the Minister of the Interior, consisting of the Government Electrician, Mr. Higman; the Metallurgist, Mr. Locke, and myself, with instructions to proceed to Lockport, N.Y., where the Ruthenburg electric furnace had been set up in the Cowles Electric Smelting and Aluminum Works and investigate the efficiency of his process.

A second Commission was appointed on December 28th, 1903, to proceed to Europe and investigate the different electro-thermic processes for the smelting of iron and the making of steel in operation in Europe. This Commission consisted of Mr. C. E. Brown, Electrician; Mr. F. W. Harbord, Metallurgist; Mr. Nystrom, Draftsman; Mr. Cote, Secretary; and myself.

In giving a short epitome of the work done by these two Commissions, the facts elicited will be presented in the order of the appointment of the Commissions. First, then, the Ruthenburg process of electric smelting of magnetite:

PLATE I.



Front view of the Ruthenburg Electric Furnace.

DESCRIPTION OF FURNACE

The furnace (see plate 1) consists of an electro-magnet (horseshoe pattern) of cast-iron, with pole-pieces of soft steel. The two limbs of the magnet are electrically insulated from each other at the bend, which, in the form of a joint, permits the variation of the gap between the poles by means of a screw. The limbs of the magnet are surrounded for nearly the entire length by closed brass drums, which are provided at the end farthest from the poles with means for rotating them in directions toward the gap. The rotation is effected by a separate motor of about ¼ horsepower. These drums serve the purpose of absorbing by water circulation through them the heat generated and of giving motion to the ore toward the gap. The parts of the drums to which the working current is distributed and which form the electrodes are armed with carbon plates. This current was furnished by two Brush Direct Current Generators, joined in series, of 50 volts and 3,000 amperes capacity each, thus giving 100 volts and 3,000 amperes.

A Weston ammeter of 4,000 amperes capacity, a Weston voltmeter, reading to 120 volts, and a Scheefer recording wattmeter, No. 42,203, specially constructed for 2,000 amperes at 110 volts, were in circuit with the main current.

DESCRIPTION OF THE PROCESS

The magnetite is first coarse-crushed and sent through Cornish rollers for fine crushing. From these it passes into magnetic separators which eliminate the non-magnetic constituents. The resulting concentrates are mixed with carbon in amount somewhat in excess of the amount needed to reduce the ore to the metallic condition. Partial reduction of the ore is expected to be effected by the working current in the gap of the carbon-covered drums, where, on account of the magnetic field, the mixture of ore and carbon forms a bridge, the carbon being held in place by the magnetite threads which span the gap. The partially reduced ore in the heated condition loses its magnetism and drops into a cooling pit, being replaced by a fresh mixture of ore and carbon; the process is thus automatic and continuous.

The partially reduced and heated ore is expected to agglomerate into masses in the pit, where it is assumed to undergo further reduction. After the cooling, the fritted mass is, according to the Patentee's account, melted in a cupola and cast into ingots, or directly transferred to an open hearth furnace and converted into steel.

CALIBRATION OF THE ELECTRIC MEASURING INSTRUMENTS

The calibration of these measuring instruments was undertaken by Mr. Higman, who employed for this purpose his own official standards. The Weston ammeter and voltmeter were found to be correct, but the wattmeter failed to record. Examination by the agent of the firm in St. Catharines revealed the fact that the lower ball-bearing of the spindle of the rotating disc was missing and that the connection of the potential coil had been broken.

The wattmeter being of special design and not kept in stock, it became necessary to send it back to the factory in Peoria, Illinois. To avoid all unnecessary delay Mr. Higman undertook to convey it to the factory and personally supervise its refitting.

DETERMINATION OF ELECTRIC ENERGY ABSORBED.

On the return of Mr. Higman with the repaired and calibrated wattmeter it was decided to make a trial run of a quantity of ore sufficient to determine the electric horse power absorbed in the furnace per ton of product. The following mixture was employed by Mr. Ruthenburg for this purpose:

Moisie, iron sands	3,200 lbs.
Sawdust	200 "
Coke, crushed	800 "
Total	4,200 lbs.

As the experiment progressed it was found that the sawdust of the mixture was only partially acted on in the gap, particles passing through without having been carbonized, and the large pieces of coke, heated to a bright redness by the current, absorbed

the electric energy without any useful return in effecting the reduction of the ore. *The iron sands and coke particles fell in a fine, fiery rain into the pit, where they rapidly cooled; the iron sands having lost their magnetism before insipient fusion had set in, the product of the furnace in the pit failed to agglomerate into masses and consisted apparently of nearly the same physical and chemical constituents as the ore mixture employed.*

The electric energy absorbed per ton of ore was found to be 0.054 horse power years.

The analysis made by Mr. Locke, the mettalurgist, proved that the reduction, as was to be expected, was insignificant.

CONCLUSION.

Whatever the claims made by the patentee for his process as exhibited to the Commission, the foregoing results of the investigation demonstrate its *entire failure* as a process for either agglomerating and fritting the finely divided ore or for any useful reduction of the iron ore.

The fact that the magnetite loses its magnetism before incipient fusion takes place will prevent the agglomeration of the charge in the pit and the narrow gap between the poles, through which the charge requires to pass, will always render the capacity of the furnace small. These two facts preclude the hope that modifications of the process will render it commercially useful for agglomerating finely divided ore in substitution for briquetting.

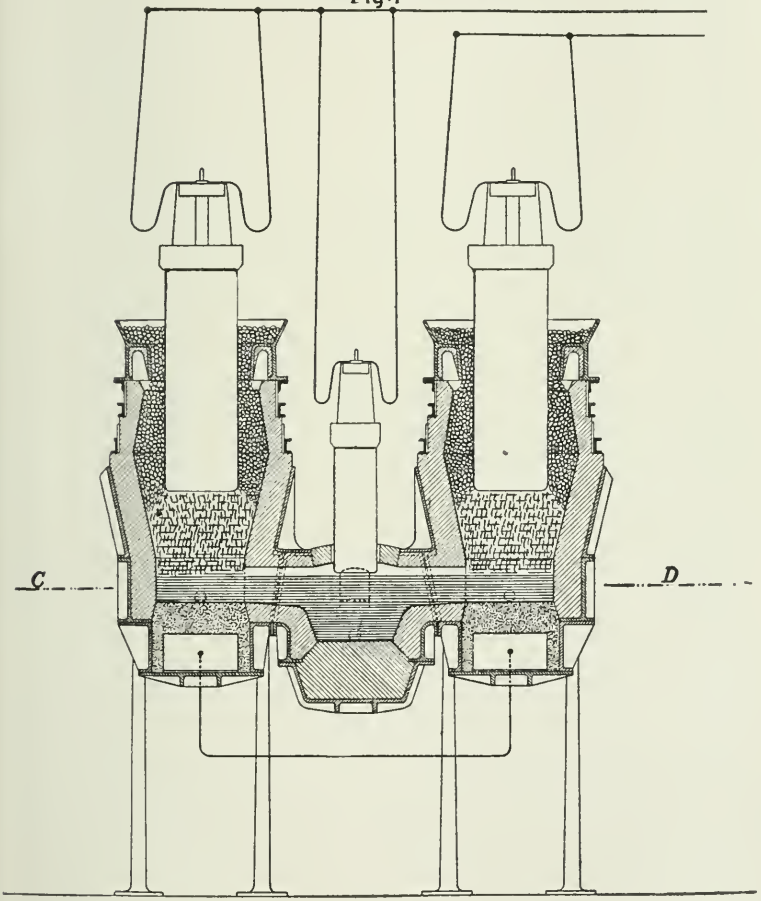
EXPERIMENTS MADE AT LIVET FOR PRODUCTION OF PIG.

In the blast furnace process the coke performs two functions: that of reducing element and source of heat. In the electric furnace the heat derived from the transformation of electric energy is substituted for the heat derived from the combustion of carbon in the blast furnace, and only so much carbon is added to the charge as is required for the effective reduction of the ore and that required to enter into combination with the iron in the production of pig.

CONSTRUCTION OF THE LIVET FURNACE.

The furnace, see Fig. 1, is of the resistance type, and consists of two iron casings of square cross-section, forming two shafts

The Keller Electric High Furnace with a plurality of Hearths
Fig. 1



communicating with each other at their lower ends by means of a lateral canal. The casings are lined with refractory material.

Two different classes of furnaces were used for the experiments. In the case of the first furnace employed, the lateral canal was widened out at its centre to form a reservoir for the accumulation of the melted metal, from which it could be tapped after the slag had been withdrawn from tap-holes, one for each shaft, situated at the lower end of the shaft, at a higher level than the tap-hole of the reservoir.

The base of each shaft is provided with a carbon block. These blocks are in electric communication on the exterior of the furnace by means of copper bars. The carbon electrodes to which the electric current is distributed pass two-thirds of their length into the shaft, and consisted of an assemblage of four electrodes of square cross-section, 280 millimeters on the side, into a single mass of square cross-section, 850 millimeters on the side and 1.4 meters long.

METHOD OF CHARGING.

In starting the furnace the charge is introduced between the carbon blocks of the base and the ends of the electrodes, which latter are then in their lowest position. The current passes from one electrode through the material to be reduced to the carbon block, from thence outside of the furnace by means of the copper conductor to the other carbon block, through the charge in the second shaft, and to the other electrode. The current meeting in the two shafts with the resistance of the charge, the latter is heated, the reduced metal flowing along the canal conducts the electric current from one electrode internally to the other electrode. The exterior current diminishes as the amount of reduced metal increases. The electrodes are now raised, the charging continues, until finally the electrodes occupy their normal positions, and the shafts below the electrodes and between the electrodes and the sides of the shafts are completely occupied by the charge. Under these conditions but a small current flows through the external conductor, the main current passing within the furnace from electrode to electrode. This ingenious arrangement of providing a shunt for the current enables the furnaces to be

worked continuously without at any time varying excessively the load on the alternator.

The iron ore, flux and coke, broken so that all would pass through a 1½-inch ring, mixed and conveyed to a platform surrounding the throat of the furnace, were charged into the furnace by hand labour. The waste gases were allowed to escape and burn at the top of the furnace.

The composition of the charge in the first set of experiments consisted of:

Ore	500	kilograms.
Coke	100	"
Lime	60	"
Quartz	30	"

The resulting iron was very grey, containing considerable of both silicon and manganese. The coke was, therefore, reduced to 90 kilograms, the lime to 30, the quartz to 10 and still later the quartz was entirely omitted. The iron was low in phosphorus and sulphur.

Tappings occurred every two hours and the molten metal was run into clay-lined, horizontal, cast iron moulds. The length of run was 55 hours. Amount of pig produced was 9,868 kilograms.

The furnace worked quietly throughout the experiments and without the slightest accident, although the current reached 12,000 amperes in one set of experiments. The carbon monoxide burned on top of the furnace in flickering flames, showing that the gas resulting from the reduction of the ore escaped without pressure. The workmen were ordinary Italian labourers, without any special training.

The electric energy expended per ton of pig in these experiments was 0.475 horse power years.

In a second set of experiments the charge had the following constitution:

Ore	525	kilograms.
Coke	95	"
Lime	15	"

This was towards the close, altered to:

Ore	500	kilograms.
Coke	102.5	"
Lime	25	"

The electric energy expended was 0.226 horse power years per ton of pig. The length of run was 48 hours. Amount of pig produced was 6,692 kilograms.

In ascertaining the electric energy absorbed when an alternating current is employed the volt-amperes read from the switch-board instruments do not furnish the watts delivered, since, on account of the reactance of the circuit, the amperes are not in phase with the volts but lag behind the volts. It is, therefore, necessary to determine the cosine of the angle of lag, or, as it is otherwise expressed, the power factor must be ascertained, that is, the figure by which the volt-amperes require to be multiplied in order to furnish the watts delivered. This determination was made for us by the director of the Electro-technical Institute of the University of Grenoble for the two machines employed in furnishing the current for the two separate sets of experiments. The voltmeter and ammeter in circuit with the furnaces were also calibrated by the same high authority.

To render ourselves independent of the switch-board instruments in the determination of the electric energy absorbed, a Thomson Recording Wattmeter, rented from the Compagnie pour la Fabrication des Compteurs, Paris, and calibrated by them was also intercalated in the circuit.

QUALITY AND KIND OF PIG IRON PRODUCED.

By adjusting the charge it was easy to obtain any grade of pig iron desired, grey, white or mottled, and castings were made direct from the molten metal of the furnace, such as columns, gear-wheels, plates, etc., all showing sharp edges and comparatively smooth surfaces.

COST OF PRODUCTION OF PIG IRON BY KELLER PROCESS.

Mr. Keller's estimate of cost per ton of product, based on the energy consumed in the second experiment and found to be 0.226 electric horse power years, is as follows:

1.	Ore (Hematite, 55% iron), 1.842 tons at $1.50 per ton	$2 76
2.	Coke, 0.34 tons at $7.00 per ton	2 38
3.	Consumption of electrodes, $15.00 per ton, 34 lbs. per ton of iron	0 77
4.	Lime, 300 lbs. at $2.00 per ton	0 30
5.	Labour at $1.50 per day	0 94
6.	Electric energy, 0.226 H.P. years at $10 per H.P. year	2 26
7.	Miscellaneous materials	0 40
8.	Repairs and maintenance	0 20
9.	General expenses	0 20
10.	Amortization (machinery and buildings)	0 50
	Total, exclusive of royalty	$10 71

Mr. Harbord has furnished reasons for assuming the mean of the determination of the two sets of experiments made, i.e., 0.350 *E. H. P. years,* to be a safer figure on which to base the calculation of cost per ton of pig produced. With this change in the amount of E. H. P. and 100 lbs. additional of lime, the cost per ton of pig is $12.05.

Regarding these costs I desire to make the following remarks:

On account of the construction of the Keller furnace with a short shaft, the utilization for reduction of the carbon monoxide evolved has been very small, only 19.5% of the weight of the carbon theoretically necessary for the reactions effected was utilized as CO. By increasing the length of the shaft and providing the upper part of the furnace with gas collectors for the purpose of utilizing the escaping gases for the preliminary drying of the charge the electric energy required would be considerably lessened. Moreover, instead of employing the costly coke, charcoal or peat-coke might be employed. Experiments were made at Livet at my request, substituting charcoal for coke, but proved a failure. The reason for this failure is easily found in the fact that the porous charcoal coming in contact at the throat of the furnace with the burning carbon monoxide was readily consumed by the oxygen condensed in its pores, as well as by the oxygen of the atmosphere surrounding it.

If the charcoal had been briquetted to reduce its porosity and gas absorbing power and the shaft of the furnace made of sufficient length to discharge the resulting carbon monoxide below ignition temperature, charcoal which can be cheaply manufac-

tured from mill refuse, but which is useless in the blast furnace, could readily be substituted for the coke now employed.

Regarding the cost of electric energy in this country, I have been credibly informed that an electric horse power year can be furnished by the development of the Chats Falls at $4.50. Undoubtedly many water powers will be found, favourably situated as regards ore supply, which can be developed as cheaply.

If, then, in our estimate of cost we substitute $5.00 for an electric horse power year and $4.00 per ton of briquetted charcoal or peat-coke, and allow for the saving in electric energy by a more economic use of the CO produced in the furnaces to be constructed with longer shafts and provided with appliances for saving the furnace gases, we would arrive at a very economic figure at which pig iron can be produced, something like $9.28 per ton.

MANUFACTURE OF STEEL.

At the Gysinge works in Sweden steel of a superior quality is made in an electric furnace of the induction type.

DESCRIPTION OF THE FURNACE.

The furnace (see Figs. 2 and 3) consists of a cylindrical iron casing partly closed at the base, resting upon a brick foundation. The casing is lined with fire brick, and that part which contains the annular groove is filled in with magnesite or silica brick, according as a basic or acid lining is required for the groove which forms the melting space or crucible. In the centre and coaxial with the annular crucible the primary is placed, to which is distributed an alternating current of 90 amperes at 3,000 volts which induces in the secondary formed by the metal in the annular crucible a current of 3,000 amperes at 7 volts. The conversion of electric energy into heat takes place, therefore, in the substance which fills the annular crucible.

PROCESS.

The process, as carried out at Gysinge, consists in melting together Dannemora charcoal-pig and Wallon scrap in such proportions as will insure the proper carbon content in the steel produced.

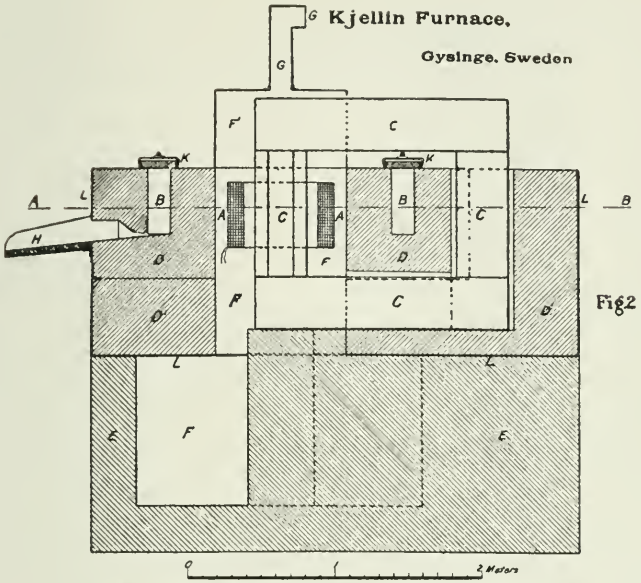


Fig 2

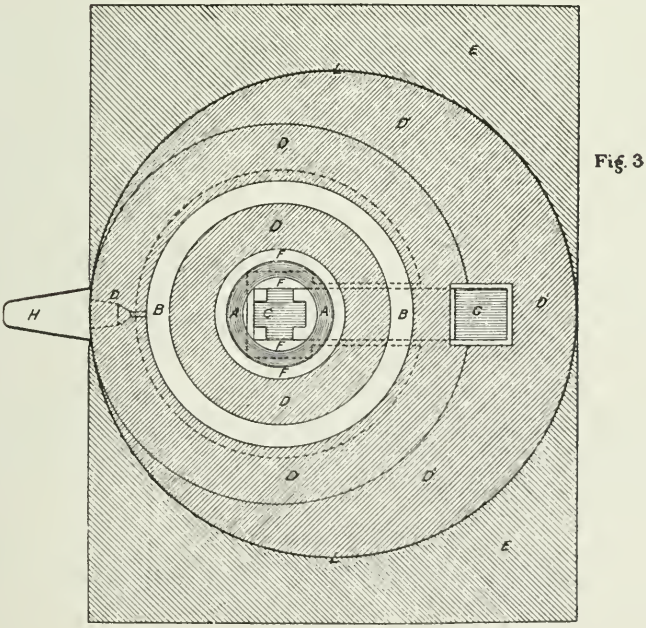


Fig. 3

Section A B

The following is the composition of the charge for the steel of their usual manufacture:

White pig iron	300 kgs.
Steel scrap	125 "
Bar scrap	600 "
Metal in furnace,	700 "
Silicon pig	30 "
Ferro manganese	1 "
	1,756 kgs.

The crucible is never emptied completely, but about 700 kgs. are left in it at each tapping to maintain the current.

The time required for melting down this charge and getting it to the proper temperature is 6 hours, when it is tapped into ladles and teemed into iron moulds. The electric energy required per ton of product is 0.116 E. H. P. years.

EXPERIMENTS MADE.

Three different grades of steel were made for the Commission:

1st. The regular steel with carbon content of 1%, for which the furnace had been specially designed. Electric energy required per ton 0.116 H. P. years

2nd. A steel containing about 0.5% of carbon which was obtained without difficulty, but at a greater expense of electric energy. The electric energy per ton required for this steel was 0.145 E. H. P. years.

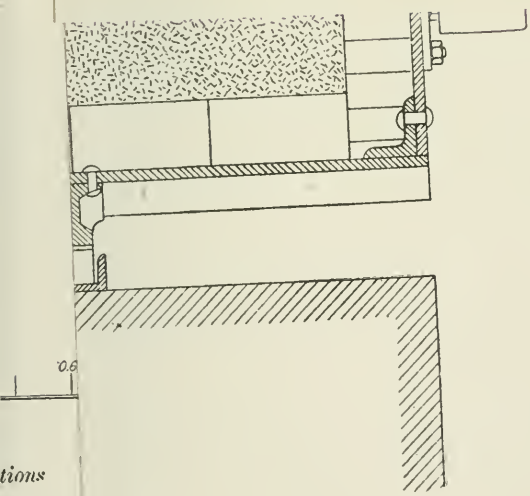
3rd. A very mild steel containing about 0.1% of carbon. This grade of steel was produced with considerable difficulty. The electric power necessary to bring the contents of the crucible up to the proper tapping heat was not available.

QUALITY OF STEEL.

The experiments made with the Gysinge steel containing 1% of carbon at the Woolwich Arsenal proved the steel to be equal to the best crucible steel manufactured.

ELECTRCAL MEASUREMENTS.

In order to be independent of the switch-board instruments

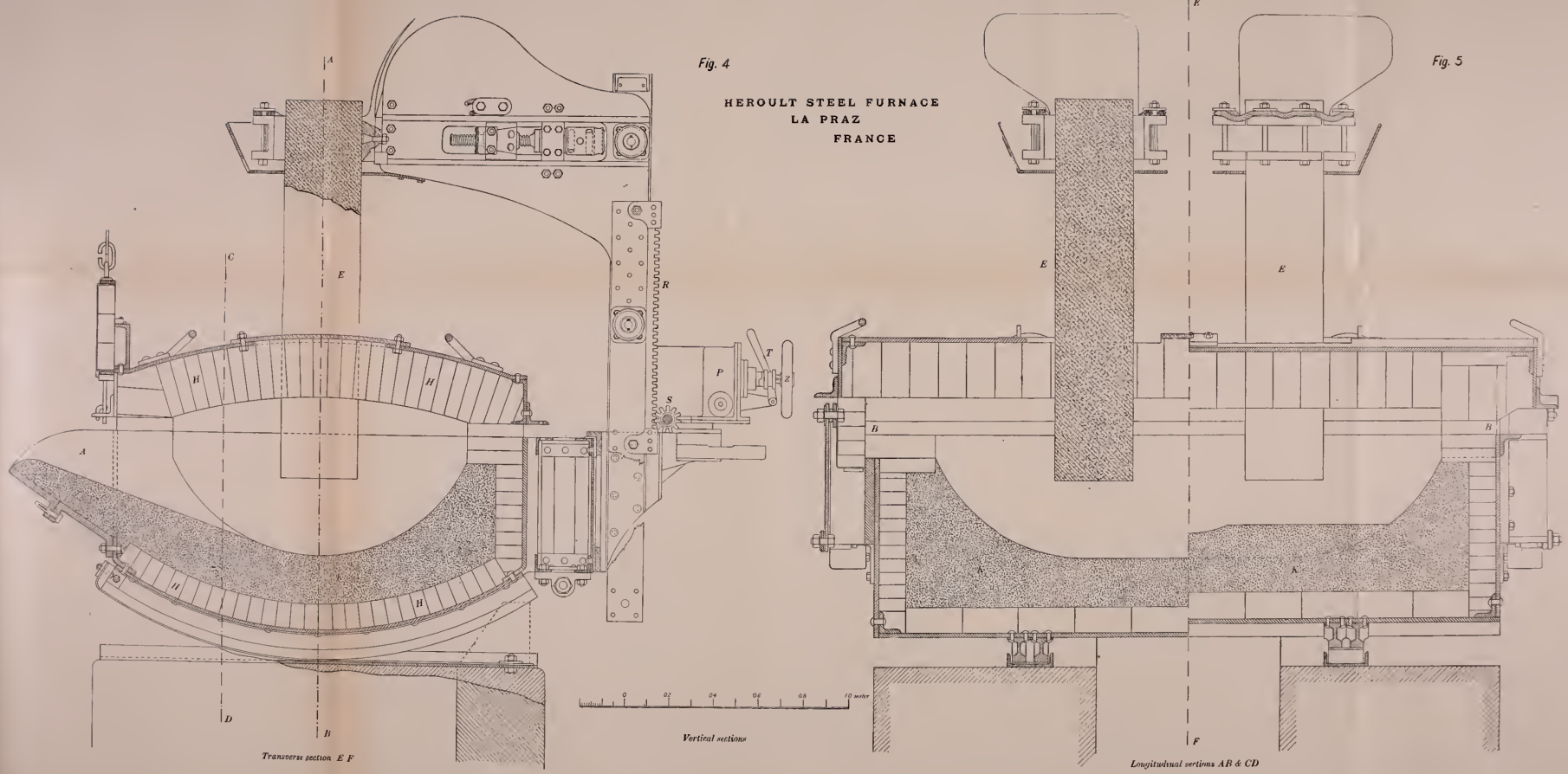


tions

Fig. 4

HEROULT STEEL FURNACE
LA PRAZ
FRANCE

Fig. 5



for the measurement of the electric energy absorbed in the manufacture of steel at Gysinge standard volt and ammeters and a wattmeter were rented in Stockholm and placed in circuit.

The low power factor (average of first run 0.672) and the low periodicity of the alternator are disadvantages which are inherent to the system employed, but the fact that the furnace takes current directly at a voltage suitable for generation and transmission over moderate distances, requiring neither cables, special connections, nor electrodes, with their attendant cost, loss of power and necessity of attention are important advantages.

COST OF THE STEEL PRODUCED.

Materials	$31 66
Wagers	2 66
Renewals and repairs	0 60
Electric energy	1 48
Ingot moulds	0 48
Interest and redemption	0 60
	$37 48 per metric

ton, or $34.00 per ton of 2,000 lbs.

The process as practiced at Gysinge with the present construction of the Kjellin furnace does not permit the purification of the materials employed. The quality of the steel depends entirely upon the purity of the component materials employed. On the other hand, this process is especially adapted for the manufacture of high grade carbon steels and high speed steels, such as tungsten and molybdenum steels. The heat is generated within the material itself, is not subjected to absorption of gases nor impurities from electrodes.

The capacity of the furnace at present employed is small, the output being a little over 4 tons per 24 hours. For a larger plant Mr. Kjellin proposes that three furnaces of 15 tons capacity each of the pattern now used be united into a compound furnace, each separate furnace surrounding a leg of a three-phase transformer and made common in the centre.

LA PRAZ.

At La Praz steel of different grades is made from miscellaneous scrap by the Héroult process.

DESCRIPTION OF FURNACE.

The furnace (see Figs. 4 and 5) is of the tilting pattern, in shape much like the tilting Campbell furnace.

It consists of an iron casing lined with dolomite brick and magnesite brick around the openings. The hearth is formed of crushed dolomite, rammed on top of the dolomite brick lining of the bottom of the iron casing. Two electrodes pass through the roof of the furnace, which, in the Kortfors furnace, were water jacketed for a short distance above and below their passage through the iron casing of the roof. The current passes from one electrode through the narrow air gap left between the electrodes and the slag line, into and through the slag to the molten metal, along it, through the slag and the second air gap to the other electrode.

ELECTRODES.

The electrodes are square prisms 360^{mm} on the side and 170^{cm} long. They are made from retort coke which contains from 1% to 2% of sulphur. The binding material is tar.

PROCESS.

The scrap is charged through the doors with some lime, melted down and purified by the making of a number of slags and carburized in the furnace by carburite.

MEASUREMENT OF ELECTRIC ENERGY.

The electric readings were taken on the regular switch-board voltmeter and kilowatt-meter. No ammeter was in circuit. The average voltage was 110 volts, the mean kilowatts, full gate open, were 340.

An automatic regulator controlled the position of the electrodes relative to the bath, and kept the voltage between them and the bath constant. Two volts difference either way brought the regulator into action. Whenever the current fluctuated violently, as in the melting down of the scrap, the automatic regulator could be switched out, and the regulation effected by hand.

EXPERIMENTS MADE.

The following experiments were made for the Commission:

1st. Low carbon steel for transformers:

The following is the composition of the charge:

Miscellaneous scrap	3,307 lbs.
Iron ore	330 "
Lime	26 "

When metal and slag had been completely melted the slag was poured off, great care being taken to ensure the complete removal of the slag. A new slag was then made by adding 55 lbs. of lime, 15.5 of sand and 15.5 lbs. of fluorspar. This was melted and kept in the furnace for some time. It was then poured off and the last traces of it raked off from the surface through the pouring door.

A third slag of similar composition was then made as a finishing slag to remove the last traces of impurity, and then poured off; 1.5 lbs. of ferro-manganese were added, and the charge was poured into a ladle, a little aluminum was thrown in before the metal was teemed into ingot moulds.

On account of the smallness of this charge the time for working was only 4½ hours, and since the product was low in carbon no time was required for recarburization. The steel when teemed ran freely from the ladle, leaving no appreciable scrap. It was quiet in the moulds, and the ingots were exceptionally sound for steel of this quality.

The electric energy consumed was 0.153 E. H. P. years per ton of steel produced.

2nd. High grade carbon steel. The steel produced by the second experiment had the following composition:

C	1.016
Si	0.103
S	0.020
P	0.009
Mn	0.150
As	0.060

Time for working, 8 hours.

Electric energy consumed, 0.153 E. P. H. years per ton of steel produced.

If the metal had been tapped before recarburization, the electric energy consumed would have been 0.1 E. H. P. year per ton.

QUALITY OF THE STEEL.

These steels have been examined for us regarding their wearing qualities as tool steel by the officers of the Woolwich Arsenal, and pronounced to be equal to the best crucible steels.

I may here mention that for lathe tools in large machine shops crucible steel is no longer employed as tool steel, Tungsten and molybdenum steels, or what are termed high speed steels, being exclusively used for lathe, planer and similar tools.

There is no difficulty of producing these steels by the Héroult process, ferro-tungsten or ferro-molybdenum need only be added in appropriate amounts before casting.

COST PER TON OF PRODUCT.

Raw scrap	$12 00
Electrodes	0 20
Electric ener y	1 53
Repairs and renewals	1 40
Labour	1 86

The capacity of the Héroult furnace described is small, about 4 tons in 24 hours; this has been increased to 7 tons by the addition of water-jackets around the electrodes, but without altering the design of the furnace its capacity could readily be increased to 15 tons.

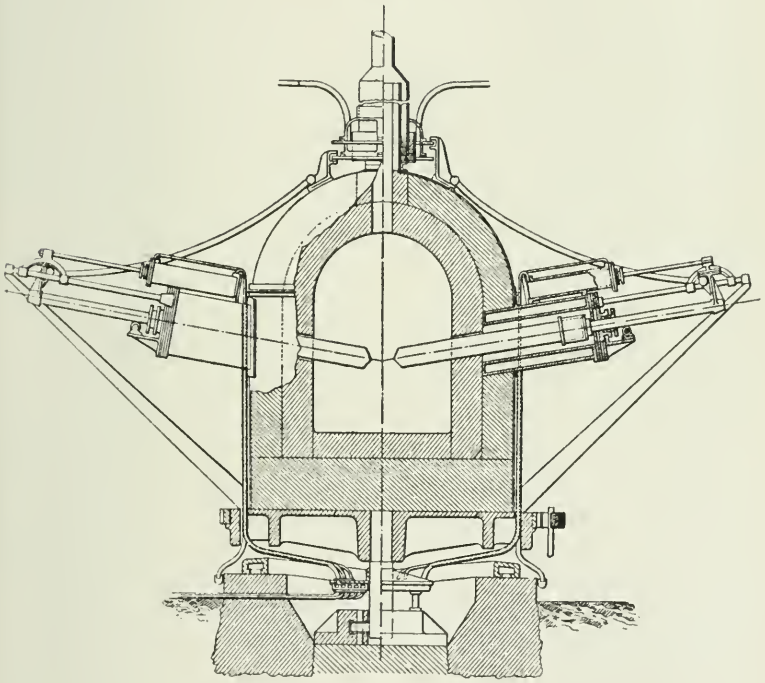
THE STASSANO PROCESS.

To put carbon into iron in the production of pig and take it out again by a second process in the manufacture of steel, appeared to Captain Stassano an irrational and uneconomic proceeding, and he devised, therefore, a method for making all grades of iron and steel direct by one operation. For this purpose the quantities of ore, flux and carbon are calculated out to furnish by reaction the class of iron and steel required, briquetted and subjected to the heat of the electric arc in his furnace.

DESCRIPTION OF FURNACE.

The furnace (see Fig. 6) is of the arc type, and consists of a cylindrical outer casing of iron, surmounted by a conical roof. The furnace is lined with formed magnesite brick. The axis of the furnace is inclined to the vertical by a small angle, and during the operation of smelting the furnace rotates about its axis, thus

Fig. 6



agitating the charge and bringing constantly new material to the surface to be acted upon by the heat from the arc, which assists greatly the reactions which require to take place in the reduction of the ore.

A three-phase alternating current of 90 volts between the phases and 400 amperes is distributed to the three electrodes

which nearly meet in the centre of the interior of the furnace. Their distance apart is varied, as required by a hydraulic regulator.

Since nothing is present except heat and the materials which enter into the charge, the calculations and results should agree. This Captain Stassano has demonstrated to be really the case by an elaborate set of experiments.

The Commission has unfortunately not been able to make a trial run, and determine experimentally the figures which enter into a determination of the cost of product by his process since his furnace was out of repair, the roof lining having fallen in and the refractory bricks ordered from Austria for repair, not having arrived. And while I cannot, therefore, speak with authority about the efficiency of his process, we need to be reminded that a metallurgical process which appears to be more simple than another process is not, therefore, necessarily the more economic.

GENERAL REMARKS.

The modern blast furnace and the different methods for the making of steel, as at present employed, are the results of a hundred years of experience, and have reached their present perfection through many modifications, which in many instances were accepted and introduced into practice only after much hesitation and opposition. The electro-metallurgy of iron and steel is of very recent date, and although high class steel has been commercially produced and put upon the market for a number of years, no plant as yet exists where iron ore is commercially reduced to pig by the electric process.

But when we consider that the experiments made at Livet were made in furnaces not at all designed for the production of pig, and furnished a figure of cost which permits comparison with the cost of pig iron produced by the highly developed metallurgical appliance, the Blast Furnace, we have every reason to expect that the electrothermic process for the production of pig will be successfully introduced in regions where water power can be developed *cheaply* in the immediate neighborhood of extensive

iron ore deposits. When it is further understood that the electric process is applicable also to the smelting of ores, such as copper, nickel, etc., that the furnaces are of simple construction, the temperature available 1,000° above that of the blast furnace and the regulation of the heat supply under perfect control, we may expect that the near future will witness the solving of the difficulties encountered in the smelting of ores which up to the present time have proven refractory to all economic processes known. I need only mention that the treatment of the highly titaniferous iron ores, of which enormous deposits exist, have resisted successful treatment by the Blast Furnace method of smelting. Mr. A. H. Allen, of Sheffield, who has made experiments in this direction, states: "that by making a highly acid slag it was possible to smelt such ores, though resulting in the wear and tear and detriment of the blast furnace and of the blast furnace manager."

Mr. Keller, of Livet, however, has shown that the New Zealand iron sands which contain 9.3% of the titanic acid can be treated with perfect success in the electric furnace by the employment of an ultra-*basic* slag and extreme hot working. The slag took up the whole of the titanic acid and was found on analysis to contain 14% of it. Of course, such ultra-basic slag, on account of its high melting point, could not be rendered fluid with the temperature available in the Blast Furnace.

Regarding the conclusion arrived at by Mr. Harbord, the Metallurgist of the Commission: that *at present* structural steel to compete with the Siemens or Bessemer steel cannot be economically produced in the electric furnaces and such furnaces can be used commercially for the production of only very high-class steel for special purposes, it is important that the emphasis be placed upon the words "at present." His conclusion is based upon the furnaces examined by us, the capacity of which was small, as it always is with appliances for the exploitation of new processes, but there is nothing inherent in the nature of electric furnaces which would prevent their being constructed of sufficient size to have a capacity equal to the Siemens open-hearth furnace and the engineering difficulties which may present themselves in arriving at a modification of design necessary for such increase

of capacity are not likely to be found insuperable. We need only look back in the history of metallurgical appliances to note in almost every instance the gradual increase in capacity from a very small output at the beginning.

Thus, the size of blast furnaces toward the close of the 16th century permitted only an output of three-quarters of a ton per day of 24 hours. This increased in 1800 to 3.3 tons per day and iron men of that day would have thought it incredible, perhaps impossible, to increase, as is now done, the capacity of the Blast Furnace to 500 tons per day.

Again, 30 years ago 30 tons of copper ore per 24 hours was regarded as fair duty for a copper furnace, to-day such furnaces have a daily capacity of some 300 tons. The original Siemens open-hearth furnace (1868), had a capacity of only 3 or 4 tons, modern furnaces have a capacity of 40 to 50 tons.

In view of this, who is to say that structural steel cannot be made in electric furnaces simply because the present furnaces have, as is natural in all beginnings, a small capacity?*

There is no question in my mind that we are on the eve of great achievements as regards the application of electric energy to the extraction of metals from their ores and that the energy of the splendid, abundant and as yet undeveloped water-powers of Canada will ere long be employed for metallurgical purposes.

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* Mr. Harbord in his paper on the Recent Developments in Electric Smelting in connection with Iron and Steel, read before the Faraday Society on March 6th, makes the following additional remarks regarding the construction of furnaces of sufficient capacity for the economic production of structural steel by the application of electric energy :

"So far as the steel works engineer is concerned, there is no difficulty in designing a furnace of any size required, as furnaces very similar in general design to the Héroult furnace, holding 200 tons of molten steel, are at present working both in England and America, and it only remains for the electrical engineer to arrange for the electrical heating without unduly weakening the roof or other parts of the furnace. Provided this can be done, under favourable conditions, where electric energy is so cheap that it can compete with producer gas as a heat producer, there is not the least reason why the present 5 ton electric furnace should not develop into a 40 or 50 ton furnace, in the same way that the 5 ton ordinary Siemens furnace has developed during the last twenty-five years."

DISCUSSION.

The President—I am sure, gentlemen, you have all been highly pleased, as I have been, with the admirable description by Dr. Haanel of the electric furnaces in France, Sweden and Italy, and the results as condensed by Dr. Haanel are most interesting. This new process will some day, no doubt bring great results to Canada, especially in Quebec and C tario, where we have so much iron and other ores and no fuel, and no doubt our country will be one of the first to benefit largely from the results of the extensive and careful researches of the commission headed by Dr. Haanel.

Mr. Kirkpatrick—Electro-metallurgical processes for reducing ores appear to be playing a very important part in the present day development. Besides the reduction of iron, so ably described by Dr. Haanel, processes are being devised for the treatment of most of the other metals. For instance, the electric smelting of zinc, which, I think, is referred to in another paper before the Institute at this meeting, should be very interesting. The blast furnace for iron is a very efficient machine, but the ordinary metallurgical process of treating zinc ore is not efficient.

Prof. Stansfield—I have listened with great pleasure to Dr. Haanel's paper. I would, however, like to ask him what is the most economical method of making the carbon electrodes, and what amount of these electrodes was consumed in the smelting of iron ore.

Dr. Haanel—I have the information, but it was given me in confidence by the Keller people, who prefer not to patent their process, but keep their shop-practice of constructing their electrodes a secret.

Dr. Goodwin—Before the discussion is closed, I should like to say one word. We have been informed that the demand for back volumes of our Journal is greater than the supply, and it is by the publication of such papers as the one Dr. Haanel has contributed to our transactions that we must look for an explanation for this demand. I consider Dr. Haanel's paper to be one of the greatest value, particularly as it brings

before us a new process in a striking manner, and calls the attention of Canada to a matter that will, no doubt, in the future, become of the greatest economical importance to the country.

Mr. Mills—I should also like to signify my appreciation of Dr. Haanel's paper. The exact and skilful care with which these investigations have been carried out by Dr. Haanel render them extremely valuable.

Prof. Stansfield—With magnetite running 70 per cent., what would be the comparative cost of treating these, and 50 per cent. ore?

Dr. Haanel—We have made no experiments with magnetite, and no figures regarding cost of production can, therefore, be stated. Magnetite differs from hematite in that the former conducts the electric current to some extent, while the latter is an insulator. There is no doubt, however, in my mind that magnetite ore can be successfully and economically treated by the electro-thermic process.

The Grondal process of concentrating and briquetting low-grade ores opens up a great future for the use of the magnetic iron sands of the lower St. Lawrence. from the fact that the wet process of magnetic separation employed by Grondal reduces the titanic acid content of the iron sands to one-half of one per cent., according to the statement made to me by the inventor. The concentrated sands are briquetted without a binding material, placed on carriages and slowly sent through a long furnace, where, coming in contact with an oxydizing flame, the briquettes are partly converted into the higher oxide, Fe_2O_3. This chemical change effects the cementing of the particles of the iron sands and renders the resulting briquette solid enough to stand the crushing force of the blast furnace, and yet so porous that 30 per cent. of its volume is interstitial spaces. This porosity facilitates reduction in permitting the carbon monoxide to penetrate into the interior of the briquette. Magnetite in the massive form is usually so dense that reduction only goes on at the surface of the pieces, and slowly passes inward. To overcome

this difficulty, it is the practice in Sweden, before charging the magnetite into blast furnaces, to first roast it, which renders it to some extent porous and more easily reducible.

The President—I am very glad to hear Dr. Haanel's reference to the treatment of our iron sands, for this is an important matter in the Province of Quebec.

CANADIAN METALLURGICAL PRODUCTS FOR THE FAR EAST.

By FREDERICK HOBART, New York.

It is hardly fair to dignify by the title of a paper what is, at best, intended to convey a few suggestions; and some of them are not new. The mineral production of Canada is increasing on certain lines, and now needs, or will soon need outlets for the surplus over domestic consumption. It seems to me that Canadian producers can do better than to look entirely to Europe and the United States for such an outlet, especially as the Pacific Coast of the Dominion is the section where the surplus is most likely to exist.

The Far East,—China, Japan and India,—is the region where new markets are to be found to the best advantage. China is a consumer on a considerable scale; the country possesses mineral resources but they are imperfectly known and have been developed, if at all, in a very limited and imperfect way.

We can hardly gauge the actual consumption of metals, owing to the absence of all reliable statistics, but the imports or purchases of foreign material can be ascertained. Japan is different: there, the metals are mined and treated in a modern and intelligent way. The resources are limited, however, and the country cannot supply its own needs with the sole exception of copper. India is not a mining country. In spite of its vast extent the mining and metallurgical output is insignificant, and the needs of its people must be supplied from abroad.

One of the more important of the metal products of Western Canada is lead, and there is complaint of an insufficient market. Canadian lead is shut out of the United States by a high duty and of Europe by the long railroad haul to the Atlantic seaboard. Now from the best attainable information,

China and Japan buy yearly from 35,000 to 40,000 tons of lead. To this, India adds 10,000 or 15,000 tons more. Much Canadian lead has already gone to the East; but there is no reason why a great deal more should not be sent.

The chief competition to be met with here is from mines of the Broken Hill group in New South Wales. They have been favoured by the proximity of Sydney to the Chinese ports, but the bounty now paid on Canadian lead ought to compensate for the difference in freight rates.

Lead prices in the East are governed by the London market, but Canadian lead is ruled by the same market if sent to Europe, and the chances are that it would bring a better return if sent across the Pacific.

During the past half year Chinese merchants have been large buyers of copper in New York. In part this demand has been due to the extra demand caused by the Russian war, which has absorbed much of the metal which Japan formerly sold to China; but in part it is certainly due to an increase in consumption in China itself, the cause and extent of which we are not yet able to determine, though there is no doubt that it exists.

I have seen recently copper from the Lake Superior mines, shipped from Houghton directly to Hong Kong, by way of Seattle, requiring rail transportation across half the continent, with its attendant charges.

British Columbia is getting to be a large copper producer. Why should not copper from the Boundary District, from Vancouver Island, or from Rossland, go to China, when it has to pay little more than the ocean rates?

When our zealous member, Mr. Gardé, succeeds in establishing a zinc smelter in British Columbia—which I hope he will do—there is little doubt that a market for some of his spelter can be found across the Pacific. Brass and bronze are in large use in Japan and China and there is little zinc ore known in either country.

A great hope for future Trans-Pacific trade is to be found in the possible building up of an iron industry in British

Columbia. Canada has then what the United States does not possess on the Pacific Coast—iron ores and fuel suitable for metallurgical work. Across the Pacific are countries which buy iron and steel and will continue to buy it; China, because of lack of mine development and of metallurgical skill; Japan, because the country is deficient in iron ores. Moreover, the loss of the market in Manchuria and Korea, which was threatened by Russian domination, seems likely to be averted. There is a great prize waiting in the Far East for American iron-makers, and the advantage will be with those who can locate themselves on the western coast of the continent. It is even possible that they can compete with the British, German, and Belgian mills, which now supply India.

Australia is also a large market for iron and steel, and all efforts to establish iron manufacture there have failed, thus far, owing to a combination of circumstances, which is likely to limit production in the future also.

These are only suggestions, and have, as I said before, doubtless occurred to others also, so that I do not pretend to claim originality for them. They resolve themselves all into a simple sentence.

The Far East needs metals; why should not Canada have its share in supplying the demand?

DISCUSSION.

The President. — The suggestions thrown out by Mr. Hobart, about the iron manufacturing on the Canadian Pacific Coast, are very good ones, and in connection with this I am sorry that the paper by Mr.Blakemore is not here, as it treats of that very point, but we hope to have it before long and to publish in the journal. I have much pleasure in extending the thanks of the Institute to Mr. Hobart, and I think that the members of the Institute should feel indebted to him with regard to the suggestions as to the possible exports to the Far East of Canadian metallurgical products and the securing of

new markets for these products there. Our silver should also find a very large market in China and India.

A Member.—The prospects in Asia are not very good at the present time, but if ever China wakens from her sleep, and takes a position in the world, it will mean much to the industrial developments of the Pacific slope. I, for one, do not feel apprehensive of what is often referred to as the "yellow peril." We have in the case of Japan, a country which, in the past fifty years, has reached a position as one of the great nations of the world, and that surely, instead of being a cause for alarm, is one for congratulation. I see no reason why the same state of affairs should not be attained in the case of China, and if we have the millions comprising the population of China, drawing upon us for many of their needs, it must lead to very material industrial development in this country.

Mr. Garde.—Mr. Hobart's paper has afforded me much satisfaction. I have studied the situation for a number of years, and have the greatest confidence in the future of the West. Development for the next few years should be very rapid, particularly in view of the building of another transcontinental railway.

Mr. Bateman.—Mr. Hobart, in speaking of the Orient, as a possible market for British Columbian lead, copper and zinc, refers to the competition that may be expected from Australia, mentioning the Broken Hill mine as one of the sources of supply. I understand that at that mine there are about two million tons of tailings running 18 per cent. zinc, and that they are being turned out at the rate of about 12,000 tons per week. There is also some talk of the establishment of a plant for the production of zinc. If such a plant were erected, could Canadian zinc successfully compete with the product from this Australian property?

Mr. Garde.—I do not see how they could, as there are no coal fields there. Also there would be less lead in the Canadian ores, which are higher grade in zinc. They have been experimenting with the Broken Hill tailings for several years.

MINING STATISTICS.

By Frederick Hobart, New York.

The question of the collection and use of mining statistics is like all others, in that it has two sides—the theoretical and the practical. The theoretical side has been so well treated by our president, Mr. Coste, at previous meetings, that I shall have little to say about it. Some experience in the collection and presentation of such statistics have, however, given me definite ideas, the brief presentation of which may be of service.

The first question is, what is the use of such figures? That, I think, is readily answered. A knowledge of the work done is essential for the benefit of producers and traders. To the miner and smelter it is of great importance to know the course of production which may seriously affect the value of his own output. The figures of production in all metals, for instance, have an important bearing on trade. Under or over-production are very important factors. To know what has been done in a given period, and to know it as early as possible, is the chief object of the practical worker. Thus, the approximate return of output for a given year, or other fixed period attainable, say two or three months after the close of that period, is far more valuable than the exact returns published ten months or a year later. Accessible at the earlier date they serve as a guide; later their value is only historical.

The Mines Section of the Geological Survey of Canada has set an excellent example in this respect. Its figures are now before us, and for several years past it has been the practice to present them about this time. The labor involved in this can only be appreciated by those who have done similar work. The United States Geological Survey also collects statistics, but its figures are not usually complete until about a year after

their date; that is, the returns for 1903 were not published in full until almost the close of 1904. For this reason, the work of the Survey has, for a number of years past, been forestalled by private enterprise. Though I have had a part in that work, I think I am justified in saying that it has been acceptable to the mining public. I know that it has proved successful and profitable, showing a definite appreciation.

No one, of course, can claim perfection for his work. I will say, however, that I have found the great majority of producers willing to co-operate and assist by furnishing definite figures at the earliest possible date; only requiring a promise that the information furnished shall be used only in making up totals, and that individual returns shall not be published. Without any official backing, I have found that producers realize the advantages referred to above, and are willing to aid, even at the cost of some trouble to themselves. A few exceptions are found, and one important company, which is, unfortunately, run on the "blind-pool" basis, persists in withholding all information. It does not take even its own stockholders into the confidence of its managers. Outside of this one conspicuous offender, there are very few who do not willingly furnish returns.

Perhaps I have discussed too much on this point, but I want to present the practical points as fully as time will permit, because I realize how strongly the other side has been heretofore presented to you. We have a clear, printed, brief, easily understood statement of production, which is undoubtedly of use to mining men; which can, as a rule, be prepared and presented in a reasonable time and at a possible cost of money and labor; and which commands the support and assistance of the great majority of producers. How successful this is, in a practical way, may be shown by the fact that the estimate of output of one important metal, made and published only five days after the close of the year 1903, varied from the full and corrected figures, secured later, by only four-tenths of one per cent. I trust you will not take this as a boast, but only as an example of what can be done in practice.

So far, I have only considered the relation of statistics to the mining world. To the general public their principal value is to convey a definite impression of the importance and standing of the mining industry, and its claims upon their regard and consideration.

This brings us to the question of valuing production. My own experience has not led me to attach much importance to values. The main point to be known usefully is the quantities. The value is simply a counter which enables to state a total. One cannot add together ounces of gold and tons of iron ore; it is necessary to find a common unit. And here a question of some difficulty presents itself, in the determination of prices. In valuing metals, for instance, what price shall we take? The one standard easily accessible is the current or average price at important market centres. It is true that the value at mines or smelters is somewhat below that. There are freight charges, perhaps refining charges and other deductions to be made. But if we once attempt to make these, we are lost in a sea of uncertainty. We have cast loose from our definite standard and cannot find another with certainty. My own belief is that it is better and fairer to accept standard prices at the commercial centres as a rule. It involves a slight over-valuation, but the proportions to the total of the mineral product are so small that they cannot be considered misleading.

In all statements of mineral values there must enter of necessity some arbitrary element. Thus I had recently to go over the accounts of a certain coal mining company. The books were well kept, the statements clear, and the case was a plainer and simpler one than is often found. I give below a summary statement, using round figures which can be more quickly grasped.

The total product for the year was 2,000,000 tons, of which in the disposition made, 600,000 tons were classed as run-of-mine; 600,000 tons lump, which means, under the Western schedule, coal passing over an 1¼ in. screen; 350,000 tons nut, or coal passing through an 1¼ in. and over a ¾ in. screen; 450,000 tons slack, which means all passing through the ¾ in.

screens. The railroad company serving the mine took 300,000 tons at a fixed price, under a contract which gave it the right to do so and, on its side, granted the company a fixed freight rate on coal shipped. The commercial sales, on coal, amounted to 1,350,000 tons. The company operated during the year—for the first time—a coke plant, just completed, in which washed slack was converted into a fair foundry coke; about 150,000 tons being made. Now the account stands as follows, the prices being averaged for the year:

Railroad sales:				
Run of mine	300,000	tons at	$1.20	$ 360,000
Commercial sales:				
Run of mine	200,000	" "	1.30	260,000
Lump	600,000	" "	1.60	960,000
Nut	350,000	" "	1.40	490,000
Slack	200,000	" "	0.75	150,000
Total sales	1,650,000	" (av.)	1.33	$2,220,000
Made into coke, slack	250,000			
Used on operating mine, run-of-mine	100,000			
Total	2,000,000			

It may be added that the 150,000 tons of coke sold at an average of $2.30 per ton at mine; rather a low price being accepted for a branch new to the market. No by-products were saved; but one battery of ovens was fitted with an arrangement for saving the gas, which was used to make steam, thus reducing to some extent the quantity of coal used in operating the mine. This gas-saving plant is to be extended, and it is proposed to use the gas, through gas engines to generate electric power.

Now here is about as plain a case as is often found, and yet, as to 350,000 tons, or 17½ per cent. of the mine product, it was necessary to assume an arbitrary price, in order to give a value for the whole. Of course, it was not difficult to do this, but it

was still an arbitrary price. Where there is more complicating of accounts and more assumed values, how can we trust them? And four-fifths of our values are founded on assumptions.

It is for such reasons that I have been led to attach little importance to values; considering them, as I have said, only a medium through which totals can be figured out. The only rule that can be made for them is to fix a standard, and then adhere to it as closely as we can.

Turning now briefly to the theoretical, or scientific side of the statistical question, we should have all the information in detail: First, the quantity of crude or first product as taken from the earth—the crude ore mined and the cost of mining it. Then the secondary products—those which have passed through a preliminary process, but are not yet in marketable form. Such are ores milled and concentrated; mattes and the like. Then comes another stage in which the product is in an advanced stage, but still not ready. Examples of this stage are lead bullion; converter bars, blister copper, or copper bullion carrying precious metals. To be precise, pig iron ought to come under this head; it is marketable as pig, but it must be cast, puddled, or converted into steel to reach its final commercial stage.

The variety of products is great, and to give the information fully would require discrimination in many products. For instance, some iron ores can be shipped directly to the furnace, while others must be crushed, washed, concentrated before shipment. If we must make the division, and if we are to ascertain values and costs—upon which values must depend—each step, the work is not only difficult but expensive. We require the services of experts to collect the information, to determine values and to apportion costs. Moreover, the time needed to classify, arrange and present the information would be so great as to postpone the publication of all statistics so long after the period they cover, that they would be valuable only as historical records.

There is another point to be considered here, and that is the difficulty of securing such information at all. In many mining

and milling operations—especially the smaller ones—the costs of different stages of the operations are not carefully separated, perhaps not separated at all. Moreover, a great many operators, while quite willing to give general results, would resent inquiries as to details as too much inquisition into their business. They would probably decline to give the necessary information altogether and would add largely to troubles of the statistician, already grievous enough.

Finally there is the question of cost. The Mining Bureau is limited by its appropriation, which legislators are always inclined to cut down to the lowest point. The collection of detailed statistics, such as I have outlined, involves the employment of many men, some of whom must be experts who can command good pay; it requires much clerical help, and the whole expense would be decidedly beyond the means of most statistical bureaus.

I do not mean to depreciate the value of such information. For engineers, mine managers and millmen, it would have the greatest interest. Practically, however, we must be limited by the means at our command. The Chief of the Mining Bureau and the private collector of statistics must each do, not what he wants to do, but what he can do, with the means at his command. The possible result, unfortunately, comes too often—perhaps always—far short of what is theoretically desirable. Nevertheless, by such intelligent work, as is in our power, results of great use and benefit to the mining industry and the public can be attained—and, I believe, we are all trying to keep up to that standard.

DISCUSSION.

The President—We are all thankful to Mr. Hobart, one of our valued members from the United States, for presenting the subject of statistics to us again. Coming from him, the paper will be considered carefully by all of us. He has had a great deal of experience in that line. I think the only difference between us is that Mr. Hobart probably places himself

in a different point of view in regard to statistics than the one I place our Mining Bureaus. Mr. Hobart places himself in the point of view of a business man, and wants to get at the figures and at the facts as they are considered and valued in a commercial sense, and that is the right point of view for Mr. Hobart to take, representing, as he does, a great commercial paper. But, on the contrary, in discussing this subject, I have always looked at it from the point of view of our Government Mining Bureaus, and I contend that these should record annually the exact state of affairs in our country and at the places of production. Though the values are perhaps not of so much importance as the quantities, yet if we want to add up we must do it by dollars and cents, as we cannot add tons, ounces, barrels, etc., together. Government Mining Bureaus, I claim, should also record the values as at the places of production in our country, as it is that very knowledge which is desired by the country, and is the cause of the existence of the Mining Bureaus.

Mr. Hobart—There is one point I ought to have brought forward. Both in public and private elements we must be limited by what is possible. The Bureau can devote only a certain amount of labor, employ a certain number of men, and spend a certain amount of money. It is not what we want to do, or what we ought to do, but what we can do.

ON UNIFORM MINING STATISTICS IN CANADA.

By Eugene Coste, E.M., Toronto, Ont.

It is, I think, admitted by the members of this Institute that an annual uniform presentment of mining statistics by the Mining Bureaus of the different provinces of Canada would be an immense step forward in the interests of the mining industries of the country. The Dominion Government could then readily publish annually through the Mining Division of the Geological Survey, or otherwise, complete uniform mining statistics of the whole country by simply adopting the uniform tables of the different provinces. A great deal would thus be gained and nothing could possibly be lost.

For this most important reason and for other reasons set forth in my short paper on this subject, which I had the honor to present to this Institute two years ago(1), permit me to suggest the adoption of the annual publication by the Mining Bureaus of the different provinces of the following two tables:

TABLE A.—MINERAL PRODUCTION

In which the first marketed products of all mines, quarries and concentrating mills would be recorded by quantities valued at the places of production.

TABLE B.—MANUFACTURED PRODUCTS FROM MINERALS

In which the quantities of metallic or other manufactured products from smelting, metallurgical, chemical or other works, would be recorded as finally produced and marketed at these works and with the value they are sold at, at these works.

A short correspondence between the heads of the different Mining Bureaus would soon establish the place for each mineral or manufactured product, whether in table A or table B, and we would then have the perfect uniform presentment so much desired, and which would be of so much value to us all and to the country.

I append below for illustration a list of the present annual

(1) Journal Canadian Mining Institute, Vol. 6, p. 408.

products of Canada thus grouped in two tables, A and B, according to their more or less advanced state of manufacture, but as I have just said, the heads of the Mining Bureaus might conceive and agree on a better grouping of the products; and, from time to time, new products will no doubt have to be added to one or the other of the tables, and it is quite possible of course that I may have omitted some of the products now being marketed in the country and which complete mining statistics should cover.

I suggest the annual publication of these two tables by the Mining Bureaus of the different Provinces in addition and independently from the way the statistics have been presented by these Bureaus in the past, as for the sake of comparisons, or for other very good reasons it might be found desirable by these Bureaus to continue their annual presentation of other tables, with fine values or otherwise, exactly as done before.

TABLE A.—MINERAL PRODUCTION

Product.	Product.
1. Actinolite.	18. Mineral Water.
2. Asbestus, different grades.	19. Molybdenite.
3. Asbestic.	20. Moulding Sand.
4. Baryte.	21. Natural Gas.
5. Chromite.	22. Ochre.
6. Coal.	23. Ores of any metals when sold as such.
7. Corundum.	
8. Feldspar.	24. Peat.
9. Fire Clay.	25. Petroleum Crude.
10. Gold.	26. Phosphate.
11. Granite.	27. Platinum.
12. Graphite.	28. Precious Stones.
13. Grindstone.	29. Pyrites.
14. Limestone for flux.	30. Salt.
15. Gypsum.	31. Sand and Gravel.
16. Marls.	32. Stones (all sorts).
17. Mica.	

TABLE B.—MANUFACTURED PRODUCTS FROM MINERALS.

Product.	Product.
1. Aluminum.	12. Mattes or metals of any other mineral.
2. Arsenic.	13. Nickel matte.
3. Bricks (all sorts).	14. Nickel-steel.
4. Carbide of Calcium.	15. Oils (refined).
5. Cement.	Illuminating Oil.
6. Coke.	Lubricating Oil.
7. Copper matte.	Benzine and Naptha.
8. Ferro-chrome.	Gas, Fuel oils and Tars.
9. Fertilizers.	Paraffine and Wax candles.
10. Lead.	
11. Lime.	

16. Pig Iron { From Canadian Ore. / From Foreign Ore.
17. Pigments.
18. Quicksilver.
19. Pottery and Terra Cotta.
21. Sewer Pipe.
22. Steel.
20. Phosphorus.
23. Sulphuric Acid.
24. Tiles and Drains.
25. Zinc.

DISCUSSION.

Mr. Coste—I think this short paper will show what my position clearly is. What I am after is something very practical, and not only theoretical, as Mr. Hobart believes. What I want specially is the uniformity of mining statistics in the different provinces of Canada, so that we can readily get at the total value of the mining industries of the whole country and give them to the public in a presentable form. This uniformity would also be most valuable in enabling us to compare provinces together. These are the practical resuls I would like to bring about by means of this paper, and there is also another one no less practical, and that is the division of the statistics in two tables, one for raw minerals and the other for manufactured products from minerals.

Mr. Hobart—I should think it would be a good idea to have some resolution passed for a conference with the different Mining Bureaus.

Prof. Gwillim—It would be somewhat difficult to arrive at the value of the ore in Mr. Coste's classification: Take, for example, the case of ores all paying different rates as regards freight and treatment. It seems to me that Mr. Coste's proposal involves an infinity of work to arrive at valuations in these cases.

Mr. Coste—That only emphasizes the great importance of knowing what these ores brought to our people at the different localities, as that knowledge would suggest at once how it could be bettered by new railways, new smelters, etc. Nothing is accomplished without work, and lots of it, often. My idea is to record in our Governmental Statistics what happened in the country at the time and at the place of production, so as to guide us in what our people are doing and under what conditions, and in what way these conditions could be bettered.

BORNITE ORES OF BRITISH COLUMBIA AND THE YUKON TERRITORY.

By Wm. M. Brewer, M.E., Victoria, B.C.

The several occurrences of well defined contact deposits of bornite ore at various localities throughout western British Columbia and the Yukon Territory present many characteristics which make a study of them peculiarly interesting. These localities are very far distant one from the other, and up to the present time no continuity of the geological conditions from one camp to the next can be traced.

It would be entirely incorrect to describe the occurrences as occupying a belt or zone, because as a matter of fact the various camps in which this character of ore predominates are found entirely isolated from each other but possessing very similar geological conditions, and especially is there a striking similarity in the matrix of the ore. So striking is this that it is impossible to distinguish with the eye any difference between much of the ore found on Texada Island from that on Gribbel Island, nearly 400 miles north from Texada and near the entrance of Gardner channel, or for that matter that found in the White Horse Camp in the Yukon, over 1,000 miles distant from Texada or Vancouver Island, and vice versa.

Historical.

The first discovery reported in British Columbia of the indications that a body of bornite ore occurred, was from Texada Island early in the nineties, but the news attracted but little attention, because of the ore occurring as impregnations disseminated through a felsite dike which was in contact with crystalline limestone, and having on the surface no well defined walls. The discovery was considered of but little value, and was turned down by miners and engineers generally.

This occurrence of ore was found near Marble Bay, on the eastern coast of Texada Island, on an old Crown granted piece of land owned by Christie and Palmer, the former being the late well known Toronto biscuit manufacturer, and the latter the president of the Toronto Type Foundry. These gentlemen showed their faith in the possibilities of the discovery by commencing mining operations on quite an extensive scale, which have been continued ever since until the ore body has been proven to maintain continuity from the surface to the present depth of the working shaft, about 500 feet, and the present owners, who purchased the property from Christie's estate after his death about three years ago, have actually paid the purchase price, $200,000, from the profits of the ore mined, and are still shipping at the rate of 1,500 tons monthly.

Soon after the discovery of this class of ore near Marble Bay, another body, apparently entirely distinct, but only about half a mile distant, was found on Crown-granted land owned by a syndicate of Victoria business men. This property was floated as the Van Anda Copper and Gold Mining Company, with a $5,000,000 capitalization, sufficient in itself to sink it to the deepest depths of the ocean, but although owing to mistakes of the management, the company did get into financial difficulties, yet the fact stands forth prominently that the ore body has maintained its continuity in the Copper Queen Mine, to a proven depth of 680 feet, below which depth the shaft has not yet been sunk. The ore on all these properties on Texada Island has yielded excellent values in gold, silver and copper from the grass roots, roughly speaking, an average of about $15.00 per ton has been obtained and several shipments of ore from between the 560 and 620 foot levels on the Copper Queen carried as high as $20.00 per ton in gold in addition to copper and silver values.

Later, other deposits of bornite ore were discovered about three miles distant and towards the north end of the Island, but although much prospecting has been done since, it appears as though this character of ore was confined to the limited area bounded by the lines of these three properties, so far as Texada Island is concerned, and even in this limited area that occupied

by the actual mining operations on known deposits is confined to four pieces of ground each less than 1,500 feet long by 600 feet wide.

The next discovery of bornite ore was made in 1898 in the mountains bordering on Sidney Inlet, on Vancouver Island, by two prospectors, Jones and Kincaid, and later, but during the same year, other discoveries were made in the same neighborhood by McKinnon and Shafer.

During 1899 McIntyre and Grainger, two Yukon pioneers, found ore of similar character near White Horse, the present terminus of the White Pass and Yukon Railway, and further prospecting has determined that such ore occurs at intervals along a zone about 16 miles in length.

About the same time discoveries of a like character were made by prospectors from Whatcom County, State of Washington, on Gribbel Island, about 400 miles north-westerly from Vancouver.

During 1904 still another body of this ore was opened up by the Vancouver Island Development Company, under the management of Mr. Cecil, a pioneer mining man from Australia. This discovery is situated on the eastern side of Vancouver Island about four miles westerly from the town of Ladysmith, and about two miles from the line of the Esquimalt and Nanaimo Railway Company.

These are all the discoveries of well defined bodies of bornite ore reported from the coast districts of British Columbia, but in the interior, in the Similkameen district, on Copper Mountain, very extensive deposits are found, and others of less extent, on Ten Mile Creek, a tributary of the Nicola River. These occurrences in the interior, though, bear a marked difference both with regard to the geological conditions surrounding them, and the matrix in which the ore occurs, to those on the island, and near White Horse.

GEOLOGY AND MINERALOGY.

With some slight local differences, which I will refer to later, the geological conditions under which the bornite ore occurs on

the islands named (except the occurrence near Ladysmith), and in the White Horse Camp bear a striking similarity.

The oldest rocks are the limestones, but whether these belong to the Carboniferous or Cretaceous eras it is almost impossible to determine, because of having been rendered fully crystalline, therefore no fossils by which their exact age could be ascertained can be found. The late Dr. Dawson, in his reports on the geology of Canada, has classified them as probably belonging to the Cretaceous, thereby connecting them with the sandstones and conglomerates in which are found the coal seams belonging to that era, or as the same authority says, some of the limestone possibly may belong to the Carboniferous age.

The sedimentary rocks were disturbed, and tilted up from their original horizontal position by the intrusion of masses and dikes of such eruptive rocks as diabase, diorite, granite, syenite and felsite, so that the dip of the limestone, especially at its contact with the igneous rocks, is almost vertical, and rarely less than at an angle of 28 degrees.

As an appendix to the report of the Minister of Mines for British Columbia for 1903, the petrography of some of the eruptive rocks which occur as intrusions in the neighborhood where the bodies of bornite ore are situated on Texada Island is given. The samples were examined by Dr. Barlow, petrographer to the Canadian Geological Survey. They were taken from the Cornell Mine, and are described as follows:

"Felsite near shaft, second level—the ore bearing matrix—the hand specimen shows a fine grained crystalline rock of greenish gray color and earthy lustre. Under the microscope the rock has a distinctly porphyritic structure, and from the mineral content is an augite porphyrite. Finely twined plagioclase, and colorless augite comprise the phenocrysts. The former occurs in tabular form while the latter is rather irregular. The base is in great part composed of augite, with which is associated turbid granular aggregates of epidote and calcite in the interstitial spaces. Pale brown garnet (almanditic) and colorless apatite are present as accessory constituents.

Ore-bearing matrix.—The rock is a pale green granular pyroxenite, holding a large amount of accessory almandine garnet. Microscopically it consists principally of polygonal and rounded idiomorphic individuals of pyroxene. Saussuritized plagioclase and a pale brown garnet occupy angular spaces between the pyroxene individuals. The garnet shows well defined optical anomalies. This rock, from its association, is a deep-seated basic phase —possibly a segregation of the augite porphyrite.

Diabase porphyrite from second level.—The rock is fine-grained greenish in color, and has a somewhat sheared appearance. Under the microscope it is seen to be a much decomposed diabase porphyrite, and is evidently a deeper-seated portion of the magma. The plagioclase is probably near the basic end of the series. Its well developed zonal structure shows a different composition for the interior and periphery, of which the former is the more basic and much saussuritized. The pyroxene has wholly altered to a pale green pliochroic actinolite, with a separation of turbid epidote and a little calcite. Some irregular aggregates of brown biotite, numerous grains of magnetite and a few of apatite complete the section.

Ore-bearing matrix, third level.—The non-metallic minerals composing the bornite matrix are pale green pyroxene and brown garnet. The microscopic section shows that the matrix is principally garnet—similar to that already described—with a subordinate amount of colorless augite. The garnet is much cracked, and these cracks are filled with the sulphides, chalcopyrite and bornite, and these are connected with the larger grains."

No microscopical examination, to my knowledge, has been made of any of the rocks found in other camps in which bodies of bornite have been discovered, but in almost every instance the matrix of the ore is identical with that occurring on the Cornell Claim, so that the above description given by Dr. Barlow will, without doubt, apply to the same character of rock in other localities.

With the exception of the mineral claims situated near Ladysmith, those on Gribbel Island, and those in the Similkameen

district in the interior of the mainland, limestone (fully crystalline), is always found as one wall of the ore bodies, usually it forms the foot wall. The ore bodies occur usually at the contact between this limestone and the so-called felsite, but sometimes between limestone and diabase, though this rarely occurs.

The diabase, syenite, granite and diorite which occur as intrusive masses and dikes, have apparently exercised no influence over the deposition of the ore bodies, in fact in many cases, especially on Texada Island, it would appear as though many of these intrusions belonged to a more recent period than that in which the ore bodies were deposited, because some of the dikes are found to cut through the ore body, and by actual work it has been demonstrated that by driving through the dike the ore body is found on the opposite side.

In some instances, notably on the Arctic Chief Mineral claim near White Horse, the matrix of the ore near the surface is magnetite and chlorite, but about 60 feet below, these minerals disappear, and garnetite is found as the gangue material.

It would appear as though the deposition of the bornite was due to replacement, for when it occurs at the contact of limestone and felsite there is no well defined wall on the felsite side, but instead a gradual change from solid ore with a little felsite and garnetite, to almost barren felsite and garnetite, with masses and crystals of bornite shot through those rocks irregularly, and from that to the barren rocks. On the 500 foot level of the Copper Queen Mineral Claim on Texada Island the crystalline limestone wall on the footwall side is nearly vertical; it is as well defined and regular as the wall of a house; next to it were four feet of solid bornite ore, then a gradual change to barren felsite and garnetite, next about eight feet in width of absolutely barren country, and beyond that a solid body of bornite, 12 feet wide in portions of the drift, then a well defined hanging wall almost vertical, composed of crystalline limestone slickensided.

On the Victoria Mineral Claim, near Ladysmith, the bodies of bornite occur in a matrix chiefly composed of silica in large crystals. The walls of these bodies are granite, the ore bodies

themselves occurring as three distinct veins in a badly crushed zone of granite lying between well defined walls of massive granite flanked on the foot wall side by conglomerates and sandstones belonging to the Cretaceous coal measures. Limestone, either in its original sedimentary condition or altered to crystalline is entirely wanting, so far as I could see during a recent visit, when I made a partial survey of the ore bodies and the surrounding geology.

On Gribbel Island the bodies of bornite ore, so far as development at present shows, occur in a gangue composed of feldspar, garnetite and calcite, between walls of syenite schist, which close to the ore itself is very fine grained, and has been evidently subjected to great lateral pressure. Further removed from the ore body this rock becomes much coarser grained and has a more granitoid appearance, in fact, it is a question whether it should be classified as syenite or granite. A microscopical examination is necessary to settle the classification.

The crystals of feldspar, garnets and calcite in the matrix of the ore bodies on Gribbel Island are large and most beautiful specimens, the crystalization being almost perfect, and the coloring so delicate and lovely that it seems a great pity that the crystals are not hard enough to be used as gems.

So far as the ore bodies near Sidney Inlet, on Vancouver Island, are concerned, I am unable from personal observation to describe the geological conditions, but from several specimens of the ore which have come under my notice, I found that so far as the matrix is concerned it is practically identical with that of the ore on Texada Island. From descriptions which have been given me I am of the opinion that the geological conditions also are very similar.

In the White Horse Copper Camp the fact that while nearly every discovery made along the zone, in length about 16 miles, and of variable width, has been a body of bornite ore overlaid by a shallow zone of copper carbonates, there are a few instances where the surface ore is unaltered chalcopyrite, occurring under practically the same geological conditions as do the bodies of

bornite, and at about the same elevation, but in a zone which appears to lie parallel to that known as the main copper belt in which the bodies of bornite occur.

For several good reasons the development work in the Whitehorse camp has been quite limited, and when I last visited that district in 1904 I found that only on one property (the Copper King) had the ore body been prospected to a depth exceeding 100 feet. The limestone footwall on which the ore lay, had been followed down on its dip, and at a depth of about 126 feet the ore body exposed was solid chalcocite, which assayed close to 50% in copper. In the workings above, considerable chalcocite had been found mixed with the bornite, but at no point had the ore body been entirely composed of chalcocite until the depth mentioned was reached.

The highest grade copper ore that has ever been shipped from British Columbia mines in any quantity came from the Copper King during the fall of 1900 when a sample shipment of 8½ tons, which was sent to the Everett Smelter in the State of Washington, yielded 46.6% in copper.

Another feature peculiar to the ore deposits in the Whitehorse Camp is that quite frequently pockets of molybdenite ore occur associated with the bornite ore, and still another feature is that very frequently tremolite occurs as a gangue or matrix in addition to garnetite and felsite.

The geological conditions surrounding the deposits of bornite on Copper Mountain in the Similkameen District are entirely dissimilar to those in any of the other districts referred to in this paper. In fact the occurrence of ore bodies themselves bear a striking dissimilarity, for instead of the ore bodies being lenses of variable extent of solid ore in a garnetite or felsite matrix they are very extensive bodies of diabase with masses and grains of bornite disseminated through the rock with great regularity and to such an extent as to give a value of an average of about 5% copper to the ton through a width of upwards of 100 feet and beyond that limit to an undetermined width. This fact has been actually demonstrated by development work on the

Sunset Mine on which much more extensive operations have been carried on than on any other prospect on the mountain.

One of the chief reasons for my having noticed particularly the several occurrences of bornite ore in the camps referred to in this paper, is that these bodies are isolated, but in near proximity occur zones or belts of considerable extent in which are found deposits of chalcopyrite, pyrrhotite and magnetite. On Texada Island there also occurs veins of gold bearing quartz which are free milling at the surface and for a shallow depth below. In the Whitehorse Camp, though so far as at present known there are only those bodies of chalcopyrite to which reference has already been made.

The geological conditions which surround the occurrences of bornite ore are to some extent dissimilar to those which surround the other sulphide ores mentioned, except in the Whitehorse Camp. For instance, on Vancouver and Texada Island the felsite dikes which occur as intrusions and closely associated with the bornite ores, are wanting in the proximity of the occurrences of the other sulphide ores, which almost invariably occur, either in fissures in the diorite or diabase country rock or else as contact deposits between those rocks and crystalline limestone.

For this reason the theory, I believe, is warranted that the felsite has had a greater influence over the deposition of the bornite ores than have had any of the other igneous rocks, for even where other rocks are found as wall rocks there is always evidence of the presence of felsite in the matrix, and besides this fact, except in the Similkameen country, the line of demarkation between the ore and any wall rock except the felsite is not only clearly defined but invariably there is a gouge of talcose material of variable thickness, very rarely less than one inch and sometimes several inches, between the ore body and the wall, but this is always wanting when felsite forms one or other of the walls. I regret that because of constant travelling I have had no opportunity to make more thorough research with regard to the deposition of this bornite ore, and also regret that time will not permit me in this paper to more fully describe the various occurrences and call attention to other characteristics which I have noticed.

DISCUSSION.

Dr. Goodwin—Not being a geologist nor a mining engineer, I am not prepared to discuss this paper as it should be discussed, but I should like to call attention to deposits similar in character in the Parry Sound district; there bornite, sulphides, and also chalcopyrite are found very closely associated with garnet rocks. The association, so far, are very similar to those described here.

The President—Are these ores through belts of limestone in the Parry Sound district?

Dr. Goodwin—I am not well acquainted with the geology of that district, except in the immediate vicinity of the deposits. I think there must be some members present who could compare them. I was particularly struck with the large quantity of garnet rock. In one case, I think it was chalcopyrite, which was scattered and mixed in with the garnet crystals, about three-quarters of an inch in diameter, and it made very pretty rock.

A Member—The rocks in the vicinity of Parry Sound, so far as I know them, are, in many cases, limestone, and in that there are very large amounts of garnet near the copper veins. I do not know very much about the geological associations in British Columbia, but one mineralogical association I have noticed, and that is that these bornite deposits are associated intimately with the cinnabar deposits there. Near any openings that have been worked for copper, you will find openings for cinnabar in the district near Kamloops lake.

The President—Was there ever noticed with the cinnabar anything of the nature of petroleum?

A Member—I have no information on that point.

The President—I mentioned that because petroleum is found in all the cinnabar mines of California, sometimes in rather large quantities. In his paper on the Chemistry of Ore Deposits*, Mr. Walter P. Jenney, of Salt Lake City, makes some interesting notes and comments on the matter.

*Trans. Am. Inst. Min. Eng., Vol. XXXIII., pp. 445-458.

Prof. Gwillim—British Columbian copper mines are very different from those in Parry Sound. According to Mr. Brewer, the bornite there goes down very far, to 500 or 600 feet. Alterations of this kind are not usually so deep in British Columbian ore.

Mr. Dresser—We seem to find a parallel on a smaller scale at the edge of the St. Lawrence Valley. Through that district there are found bornite ores at intervals for a distance of 100 miles, from Roxton, in the County of Shefford, to the St. Lawrence River. At the St. Flavien Mine there is a dike more than a quarter of a mile in width, which reappears at Drummondville and other Roxton points to the southwest. The ores, which are very similar in character at these places, occur in the dike, and are also distributed in the enclosing rock, irregularly near it. A considerable amount of work has been done, but these places have not been in operation now for a number of years. From geological accounts, there seems to be a close similarity.

A CORRECTION IN THE CLASSIFICATION OF OUR GOLD FORMATION.

By F. Hille, M.E., Port Arthur, Ont.

It is several years since I wrote a paper on the Algoma gold deposits, in which, among other things, I also gave a description of the rock formation in which these deposits occur. I believe that it may serve to refresh the memories of some who have endeavored to take some interest in the subject if I repeat here what I have formerly written, and at the same time I might succeed in convincing certain of the later writers that the statements that they have published about the geology of our gold region are in many material points not borne out by the facts. In fact, I admit that the contents of some of these papers which have recently been brought to my notice have been my main incentive in submitting this paper to the meeting of our Institute.

It is perhaps excusable in a casual observer if he makes statements in regard to our geology, tending to show that the Archaean rocks are in most localities a strange occurrence, and, I might say, hide themselves too modestly from the searching, curious eye of the indefatigable engineer or geologist under a covering, more or less thick, of rocks which are of varying degrees of interest. But when some one comes forward with a claim that he has studied that formation closely and patiently, and on the strength of this makes assertions that are wide off the mark, then, in my humble opinion, we are justified in correcting such statements, more especially if they are liable to do us an injury. Of these statements I will select only two:

(1) "The rocks in which the gold veins occur belong to the Archaean age."

(2) "The fissures in which the gold is deposited are pinched by lateral pressure and are not true."

Taking into consideration the first of these assertions, we find that our gold rock formation extends over a considerable area, being especially well developed along the course of the Seine River, the bed of which has no doubt been intensified by

a depression, caused by these rocks, which gave to Lake des Milles Lacs and to a number of other lakes, both smaller and larger, a course for their waters. The rock of this formation is a granite, partly altered, that is to say, the mica and a portion of the feldspar have been changed into a chlorite, a change most likely produced by chemical agencies. On account of its very different appearance when compared with the common, unaltered granite, and also for the benefit of the prospectors, I gave it the name "Protogine," not with the idea of coining a new name, but on account of its similarity to a gneissitic granite, found in the European Alps, to which the same name had already been given, although the rock found here has a somewhat coarser texture. In the course of this paper I shall retain this name, for the purpose of more easy distinction from other granites which I shall have occasion to mention later.

One of the foremost outcrops of the Protogine is near Island Falls, the next, in a westerly direction, is at Lynxhead Falls; a few miles farther west we find the Calm Bay and Sawbill Lake outcrops; south of these we arrive at the north Steep Rock Lake outcrop, thence several miles to the south-west we find the same formation at Lake Harold, and lastly, at Mine Centre, where it outcrops near the point at which the Seine River enters the Rainy Lake. This last outcrop partly encircles, in almost the shape of a half moon, the Bad Vermillion volcano, with which it was doubtless intimately connected. It is bordered at the west by a still younger rock, an anorthite gabbro, and at the east by a conglomerate, the product of former ash-beds. At the north end it is in contact with the Huronian schist (Keewatin), and at the south-west it is bordered by the youngest rock of this locality, a granite, forming the core of the former volcano. At Lake Harold, Moose Lake and Spider Lake (Steep Rock), it is in contact with the green schists, which it has penetrated, and at Sawbill Lake, partly with Huronian rocks, and to the north with Laurentian gneiss. The same applies to the outcrops farther to the east. The best defined and plainest contact exposure is near

the Island Falls, where it is in contact with Laurentian gneiss. If any one ever doubted that the Protogine is a younger rock formation than the Archaean granites, he will find here the most convincing proof of his error, not only by reason of the differences in texture, color and structure, but also from the contact metamorphism and breccia that is found here and there, and last, but not least, by reason of the excellent veins that occur in the protogine, it being a fact recognized by even the veriest tyro among prospectors, that no veins, at least none of any importance or promise, exist in the Archaean granites. And in every occurrence of the protogine we find similar indications of its intrusion into the Archaean area. In some localities we find the protogine occasionally schistose or faintly foliated, but this should not mystify us nor drive us to the conclusion that it is a Laurentian gneiss. This phenomenon is common everywhere where eruptive rocks occur, and is found in connection with every kind of rock, wherever it has suffered from lateral pressure. This schistosity is especially noticeable at the walls of the veins, and is produced by the instability of movements of the rock walls.

This protogine is a pre-Cambrian, or, as it is more correctly termed, a post-Archaean rock. Its occurrence is not limited to the localities above mentioned, but it is also met with in the Lake of the Woods and Manitou regions. Our maps do not usually show the different rocks, of different age, if they are situated within the Laurentian or Huronian rock areas. Thus our protogine is not differentiated upon the maps. Are we, however, justified in classifying this formation among the Archaean, simply because it occurs, or is found in, or possesses a similarity to the rocks of that area? If so, why do we not classify the Animikie among the Archaean, although they are almost of the same age as the protogine, and rest upon Archaean granites? Perhaps because they are sediments and not eruptives.

It is an unfortunate circumstance that our geologists are not allowed sufficient time to map out the different rocks, and to portray them on the maps in different colors, as should be done, but these gentlemen who are sent out are expected to survey and examine immense areas, a thorough examination of which would

require a much longer time than that allotted to them. The consequence is that if a stranger comes in, armed with one of these geological maps, he will naturally, in making his determination, follow the description as he finds it on his map. Ergo, mistakes arise in his papers. He might only wonder at the peculiarity of the occurrence of our gold formation, and would write—as it lies here before me—"In other countries the gold is found usually in younger rocks than the Archaean." This we have now seen to be the case in our own country also, and the origin of the gold contents in the veins of the protogine is to be ascribed to a still younger rock, a granite, which doubtless had its origin in Cambrian times. This rock, not finding any other of the overlying rocks which would yield to its upward pressure as readily as the protogine, caused in this rock the faults and fissures. Its fumaroles commingled with the underground and meteoric waters, and left their contents in these cracks and fissures.

This now brings me to the consideration of assertion No. 2, in which the writer claims that "the fissures in the rocks in which the gold is deposited are pinched through lateral pressure, and therefore not true."

We have already learned above that the protogine does not belong to the Archaean age, and, as I have already briefly indicated, the veins in this rock are not pinched, but are most excellent, true fissure veins. The writer might have seen some short lenticular or gash veins in the Laurentian granite, but his experience among the rocks of this district could not have been very extensive, notwithstanding his claim, or he would otherwise have speedily arrived at the conclusion that the Archaean gneisses and granites do not contain veins of any importance or extent. He, however, makes especial mention of the Hammond Reef and the Lake of the Woods, and here we find that the rock is a protogine, and therefore not Archaean. As a matter of fact, two erroneous observations lead him to two faulty deductions.

First, he assumes the protogine to be an Archaean rock, and secondly, that the fissures in the Archaean rocks, like those of the Hammond Reef, etc., are pinched by lateral pressure, and are therefore of no extent downwards. From this he deduces that

gold does not occur in this country in rocks younger than those of Archaean age, as is the case in other parts of the world, and, secondly, that the gold occurrence is not persistent towards depth. Now we have already seen that the first observation and the deduction therefrom are incorrect, and I shall presently show that the second are likewise erroneous.

There is no doubt, as I remarked before, that there are some "gash" veins in the Archaean rocks which carry some gold, as, for instance, south of Margach station (formerly Rossland), east of Rat Portage, also south and west of Sawbill Lake, and in other places, but these localities, although adjoining the gold rock formation, have practically no connection with it, except for the fact that some of the solutions which filled the gold veins in the protogine, infiltered also to some extent into the cracks of the Laurentian granites and gneisses.

I have said that special mention was made in those papers of the Hammond Reef. But what is the Hammond Reef? It is a shattered wedge-shaped piece of protogine rock which was faulted and lifted a number of feet above the north and south sides of the same rock, and having the shape shown in Fig. 1. Hot solutions of silicic acid, sulphides of iron and copper and gold filled out its many crevices and fissures, solidifying there into quartz, copper and iron pyrites and metallic gold. This fault can be traced for over three miles, with a width of from a few feet at either end to over five hundred feet in the middle. But there exists yet another fault in this region, coming from the north and butting against that just described at a right angle, and nearly in the middle of it. Almost all the protogine rocks are faulted; at Lynxhead Falls the fault has a shape similar to that of figure 2, while at Island Falls there are several which present an appearance similar to that shown in figure 3. The cause of these faults is, as I mentioned before, a younger granite. This rock can be observed in numerous localities, breaking through the Archaean strata, often in immense bosses, and it is the youngest rock in our district.

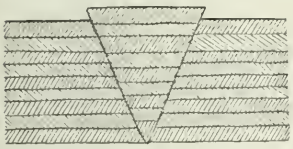

Fig. 1.

To revert now to the Hammond reef. Both sides of this fault or wedge are lined with a selvage about eight inches thick, consisting principally of ferrous and ferric oxide, chlorite and pyrite, with occasionally an appreciable amount of gold. This selvage is the altered friction product of the protogine, plus such minerals as were carried in by the thermal and meteoric waters. The author of the repeatedly quoted paper thinks that the mineral solutions leached the silica out of all these friction products and out of the crushed, granulated portion of the protogine, and deposited it in the fissures and interstices as quartz. This theory is clearly erroneous. First, because the ground or granulated portion of the protogine was not voluminous enough to furnish the quantity of silica required for the filling of the fissures. Second, because there is to-day almost as much silica in that selvage band as there

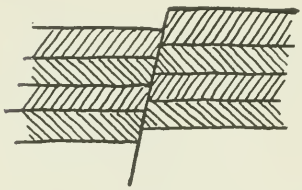

FIG. 2.

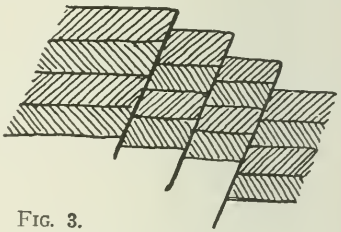

FIG. 3.

has ever been in the granite, and indeed in some places a considerably larger quantity. Third, because the protogine, both that nearest and that farthest from this selvage, shows the quartz absolutely unaltered, and existent still in the same quantities as originally laid down. Fourth, if we examine the shattered, broken parts on both sides of the cracks closely, we usually find them sharp-edged, and if it were not for the intervening quartz, we could fit the opposite pieces exactly together. Fifth, the fissures are in no instance wider than the angle of fracture and the upward lift would permit. There was undoubtedly a considerable pressure exerted on that portion, but it was not for a long enough time or great enough to crush or granulate any larger portion of the rock, on account of the fractures that already existed and which acted as slipping planes. As soon as that portion reached its highest point of lift, the different cracked or shattered parts

opened, fanlike, and the pressure was relieved. This will account for the parts of the rock along the fissures still remaining sharp-edged. I have not observed a single case in our whole gold region where the filling of the veins—quartz—could have been derived from the granulated portion of the rocks in which they were situated. If that theory had been correct, why do these veins not contain mineral from the other constituents of the granite, as for instance, feldspar, which surely disintegrates much more freely than the quartz? Too much weight is still laid upon the lateral segregation and downward percolation theory, and not enough upon the fumarolic and solfataric action, especially in the case of phenomena dating back to the time when our earth's crust was comparatively thin and the interior molten magma was still close to the exterior crust of the globe. Indeed, I venture to say that, if the granite (protogine) had been more porous, we would see more quartz in it to-day than it contained originally. I can cite numerous instances where we have an opportunity of noticing this, especially in the more permeable basic rocks, in which the hot mineral solutions carried such an amount of silica into them that, in the immediate vicinity of the veins, the rock has rather the appearance of a quartzite than that of a diorite, and this not only at or near the surface of the rock, but even as far down as 1,000 feet, as we have proved in boring with diamond drills.

I come now to the statements made by the writer alluded to, to the effect that the gold veins in the Archaean rocks, among which he includes the protogine, are squeezed, pinched veins, and that he finds considerable difference in them as compared with the silver veins in Thunder Bay district. I might almost conclude that the gentleman in question had not extended the range of his observations beyond the so-called Hammond Reef, and some of the shattered rock in the same neighborhood, and had overlooked the most excellent and true veins, striking at right angles to the reef, as well as all those hundreds upon hundreds of true veins which are found everywhere in our gold rock formation, some of which can be traced for miles and are up to thirty feet in width. The greatest depth so far reached in one of these is,

I think, 1,300 feet, and every one which has been worked showed the slickensides in such perfection that, not only in most cases did the quartz break without the slightest effort from the walls, but was also in every instance a true guide downwards. In some shafts a few feet south of the Hammond Reef, and in others a mile or two south, the observer might have seen walls so black and shining that he could have used them as mirrors.

Most of the true fissures in the protogine were produced by faulting, of which there are three instances on the Hammond Reef mine, and Sawbill mine, one on Calm Bay mine, one at Lynx-head Falls mine, and a great number in the Island Falls region, of which four are especially remarkable on account of their persistency in strike, being traceable across almost the whole extent of the formation, which is several miles long. The Manitou region has also produced some extraordinary veins, while the Rainy Lake has countless veins on a belt 3½ by 1½ miles, of which the greater number seem to have been produced by the contraction of a cooling magma, nearly all of them running or striking north and south, and being as true as one could wish them to be.

Besides the above named true veins in the protogine formation, there also exists a great number of contact veins, usually between an acid and a basic rock of which the Lake of the Woods, and several other localities as well, furnish excellent examples. Then there is yet another type of gold deposits, consisting of heavy impregnations of pyrite or chalcopyrite and gold, with sometimes also platinum, in the green schists, but these latter do not at present concern us, for the question before us now is, are the gold veins in our district true veins or not? Now I have shown that, if they are situated in the protogine, they are absolutely true. The contention made by the writer that there exists such a great difference between our silver and gold veins is based upon insufficient observation. Why? Because the silver veins are fillings of fault-fissures in the cherts and slates, and are produced by trap fumaroles and heated waters as the carrying agencies, while our gold veins are fillings of fault-fissures in the protogine, produced by granite fumaroles, with the assistance of

water. That the fillings—the quartz—should have been derived from the granulated portion of the protogine is as utterly wrong as if I were to contend that the fillings of the silver veins—the calcite, baryte, fluorite and sulphides, of zinc, copper, and lead—had been furnished by the granulated portion of the ferruginous chert or slate, the latter being former ash beds of our trap volcanoes. Such a contention would be absurd for the reason that there has never been a granulated chert or slate, and that instead of extracting calcite from these rocks, the calcite has been actually carried into them, as may readily be proved by actual observation.

THE DISTRIBUTION OF THE PLATINUM METALS IN OTHER SOURCES THAN PLACERS.

By Charles W. Dickson, MA., Ph.D., School of Mining, Kingston.

INTRODUCTION—HISTORICAL(1)

The noble metal platinum, which now rivals gold in value, was unknown in the middle ages.

It is probable, however, that Julius Cæsar Scaliger, who died in 1558, was describing platinum, in his work, "Exercitationibus exotericis de subtilitate," when he speaks of a metallic substance, found in the mines of Darien (New Granada), which "could neither be melted by any fire, nor by the arts of the Spaniards."

Many attempts have been made to prove that older writers were familiar with platinum, but with little success.

The first scientific recognition and description of platinum is contained in a book of travels, "Relation historica del Viage a la America meridional," by Don Antonio Ulloa, which appeared in 1748. In 1735 Ulloa made a voyage with a French expedition to the west coast of South America. He describes the mines of Choco (Colombia), where gold was found mixed with other metals. Many of these could not be worked on account of the platinum, which the miners were unable to extract. It is quite clear, then, that at this time platinum was a well known companion of gold, and a serious drawback to the working of the gold deposits.

In 1750 William Watson described platinum from Colombia, in the Philosophical Transactions, as a peculiar semi-metal.

Scheffer had also received platinum from the River Pinto, South America, and described it, before the Stockholm Academy

(1) Die Metalle; Bernhard Neumann; Halle, a.S., 1904.

in 1752 as "white gold," called in Spain "Platina(1) del Pinto," or "little silver of Pinto." He found it to be insoluble in nitric acid, but soluble in aqua regia; infusible in the hottest furnace; but capable of alloying with other metals.

Lewis published further researches on platinum in 1754, and Marggraf prepared the pure metal in 1757. The latter also demonstrated that a solution of platinum was precipitated by potassium salts.

In 1772 Graf von Sickingen prepared platinum foil and wire.

The first platinum crucibles were described and made in 1784 by Achard, by fusing arsenic and platinum together.

In 1800 Knight showed that platinum might be dissolved, precipitated by sal-ammoniac; the precipitate formed into a crucible and reduced to the metallic state.

Soon after the firm of Johnson, Matthey & Co. prepared platinum sponge by heating ammonium-chloroplatinate. This was pressed into a cake under water and then hammered into the required shape. In 1809, this firm made a retort in this manner, weighing 13 kilos., for concentrating sulphuric acid.

The early methods of manufacturing platinum utensils, however, involved many difficulties, and the introduction of the oxy-hydrogen blast, by Hare, in 1847, marked a decided step in advance for the platinum industry.

Platinum was discovered in Russia in 1819, and in 1825 there were twenty-five placers worked in the Nischny-Tagilsk District.

The Spanish Government at one time ordered all the platinum found to be thrown into the sea, as it was used to depreciate gold coins. Later (1778), the King of Spain claimed all the platinum, paying for it at the rate of about $2.00 a pound, and the Government finally used it to alloy with their gold coins, as a considerable quantity could be added without changing the color.

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(1) Plata=silver.

From 1828 to 1845 the Russian Government also used platinum for their coinage, using in all some 14,250 kilos.

As this coinage was recalled, the output and price dropped rapidly.

The platinum producers then found a market with Johnson & Matthey, London, who, up to recent times, fixed the price and practically monopolized the market.

CHIEF SOURCES OF PLATINUM

Every year the question of the world's supply of platinum is becoming more serious. While the demand for the platinum metals is steadily increasing, the supply remains practically constant.

The official statistics of production are not always satisfactory. Sometimes they are based on the crude, at others on the refined metal. Still, they suffice for a general comparison.

According to Joseph Struthers(1) the total annual output of the world ranges between 160,000 and 170,000 troy ounces. (5,000 to 5,300 kilos.), of which about 90 per cent. comes from Russia.

Another writer(2) states that Russia alone produced in 1902 some 7,000 kilos.

The next largest producer is Colombia, South America, which has a yearly output of about 350 kilos(3).

Small amounts also come from Canada, the United States, New South Wales, and Borneo.

It is important to note that the producing deposits are entirely confined to placers, and Prof Kemp(4) calls attention to the fact that those of a more permanent nature need only be

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(1) Extract from Min Res. of the U. S., 1902.

(2) Dr. Bernard Neumann, "Die Metalle, etc.," 1904. The author does not state if the results are based on crude or refined metal. The former is doubtless meant, and as the native metal is from 71 to 89% pure, the actual output of refined metal is much smaller.

(3) Official statistics are wanting.

(4) Bull, U.S.G.S., No. 193.

sought for on very old lands, which have been subjected to protracted denudation and concentration.

This fact itself demands serious consideration. From their very nature, placers, while important for the time being, are *never* permanent, and only open the way to mining operations on a more substantial basis in a given district.

The fact is also clear, that the present production of platinum is not *increasing in proportion to the demand.* For many purposes there is no metal to take its place, and so far attempts to substitute alloys of various kinds have failed.

As a consequence prices have been steadily rising, and will continue to rise, unless the necessary supply to meet the ever increasing demand, is forthcoming(1).

Till comparatively recently, and before its valuable properties for various technical and scientific purposes were fully understood and appreciated, the production of platinum was extremely variable. This was due to various causes. Russia was naturally the largest producer, and so was able to regulate the supply(2).

From 1825 to 1845 the output varied irregularly, annually between 1,000 and 2,000 kilos.

Then Russia withdrew from circulation and stopped minting the coins, for which a considerable amount of platinum had been used. As a result of this action, the Russian production fell off

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(1) The approximate average price of platinum per Kilo. and oz., since 1867, for five year periods, or less, is as follows:—

Year.	Price per Kilo.	Per Oz.
1867-1870	$161.50	$ 5.00
1871-1875	175.50	5.50
1876-1880	216.50	6.75
1881-1885	223.00	7.00
1886-1890	295.00	9.00
1891-1895	375.00	11.50
1896-1900	461.50	14.50
1901-1904	611.50	19.00

The prices even in a single year vary greatly, but these figures give a very good idea of the upward trend. During the last twelve years the prices have more than doubled.

(2) Up to 1870 there are no continuous Russian statistics, but for previous years figures are available, so that quite accurate calculations can be made.

rapidly. Up to the year 1856 it did not rise above 200 kilos. annually, and for a number of years fell below 100 kilos.

Then as the demand for platinum for chemical and electrical purposes became pressing, the production slowly increased. It varied mostly between 1,000 and 2,000 kilos. annually, but with a marked falling off in 1863-64, to less than 500 kilos. In 1880 it had risen to nearly 3,000 kilos, and in 1882 to more than 4,000. From 1885 to 1890 it fell several times below 3,000 kilos, but from then on has risen to between 4,000 and 6,000 kilos annually, and in 1902 reached the mark of 7,306(1).

THE DEPOSITS

With regard to the platinum deposits themselves, a word will not be out of place.

Russia.—It is important to note that the Russian sources of supply, which furnish at least 90 per cent. of the total, are comparatively limited.

The most important localities lie in Eastern Perm, along the eastern watershed of the Urals, and along the western side, further south. The length along both sides is about 130 kilometers (about 80 miles), and the platinum is found chiefly in the sands of the Tura, Tagil, Salda, Lala, and Loswe Rivers. The metal bearing sands are usually not more than a meter deep, and are covered with turf from 2 to 14 meters thick.

A matter of the gravest importance in this connection is the fact that the metallic contents of the sands are rapidly decreasing. In the Nischny-Tagilsk district, where 74.6 grams of platinum were obtained per ton in 1825, the average in 1895 was only 2.3 grams. In the district of Goroblagodat, in 1870, the sands yielded 31.1 grams per ton, and at present little more than 2 grams. In many places, however, the average is still 10—13 grams a ton. As the limit of profitable working is generally over 1 gram per ton, it will be seen that the paying sands are rapidly becoming exhausted.

(1) The official figures do not, however, convey an exact idea, as it is calculated that about 25 per cent. of the total is stolen.

OTHER DEPOSITS

With reference to the other countries, little need be said. The platinum is obtained exclusively from placers, worked for gold. The deposits of Colombia are next to Russia, the most important. Canada and the United States both supply small and varying amounts, almost exclusively as a side product from the gold placers of British Columbia and California.

In New South Wales a small amount of platinum is saved from the gold washings, but it is not of great importance.

A more important and interesting deposit is that which occurs near Broken Hill. There, platinum, in a very fine state of division, is found in what appears to be the decomposed portions of the country gneisses or schists. Platinum was first detected in ferruginous outcrops, resembling a gossan. The outcrops are irregular and never extensive, and on following them down, they pass into ferruginous clays, then into a mass of silica granules, cemented by kaolin, and finally into a decomposed feldspathic rock. This latter may represent either gneiss or a granitic dyke. Platinum is distributed irregularly through the decomposed material, but is most abundant in the clays and kaolin.

Mr. J. B. Jacquet, who investigated the deposits, claims that the metal has been deposited by springs, which issued at one time where the deposits are now found.

The deposits are interesting for several reasons. They prove that platinum is *not* confined to basic rocks, and that workable deposits are not necessarily limited to placers. Also, if Mr. Jacquet's conclusions are correct, it is evident that platinum *circulates in solution.*

Small quantities of platinum and iridosmine have been discovered in many other places, but as they do not contribute any considerable amounts, it is not necessary to enumerate them here.

OTHER POSSIBLE SOURCES OF PLATINUM

Since the first discovery of platinum, attempts have been frequently made to trace it back to its original source. In many cases the search has been largely of the nature of a scientific problem. But at the present moment the necessity for a more complete investigation of these possible sources is an economic one.

Leaving placers out of consideration, Prof. Kemp makes two other types of platinum deposits.

(1) Veins.—As at Tilkerode in the Harz; Minas Geraes, Brazil; Santa Rosa, California; Beresovsk, Russia; Guadalcanal, Spain; (with tetrahedrite and bournonite); Rambler Mine, Wyoming (sperrylite, with covellite); and Sudbury, Canada (sperrylite, with chalcopyrite)(1).

(2) Disseminated in eruptive rocks.—Native metal in basic eruptive rocks, especially periodotites, often intimately associated with chromite.

That the metals of the platinum group at times accompany copper ores was demonstrated in the early part of last century by the French chemist, Vauquelin. The ores came from a silver mine at Guadalcanal, Spain, and resembled tetrahedrite. They were found to contain copper, lead, antimony, iron, sulphur, silver, platinum, and at times arsenic. Both the silver and platinum proved to be very variable, the latter being found in quantities from mere traces up to 10 per cent. The ores occurred in an undoubted vein, and thus established an interesting fact, which is only now beginning to assume importance.

The most important discovery of platinum in connection with secondary ores, was probably the announcement made by Wells and Penfield in 1889, that a new mineral, sperrylite, (Pt As), had been identified in the heavy concentrates from the gold ore of the Vermilion Mine, near Sudbury, Ontario.

(1) Prof. Kemp classes the Sudbury occurrence with the next type, but it in reality belongs here, as the chalcopyrite is undoubtedly secondary.

Since then, it has been recognized that platinum is generally present in the nickel-copper ores of the Sudbury district.

It was also shown that the platinum was associated with chalcopyrite, rather than with pyrrhotite. Experiments carried on by the writer in 1902(1) demonstrated the fact that the platinum in the unaltered ore was also present as sperrylite.

In 1893(2) D. H. Browne stated that the ore from the Vermilion contains 9 oz. platinum per ton, and the surface sands 15.75 oz. per ton.

If these figures are even approximately correct, these ores are the richest in platinum yet recorded(3).

Platinum also occurs as sperrylite in the covellite ores of the Rambler Mine, Wyoming.

The existence of sperrylite in North Carolina, in a garnet-biotite rock, containing a considerable amount of sulphides, is worthy of mention. As far as I am aware, no attempts have been made to mine the platinum.

Platinum metals are known to be present in small amounts in the nickel-copper ores of Norway and Sweden. Recently also they have been detected in the copper ore from the Key-West Mine, Bunkerville, Nevada. The writer's experiments with these ores will be detailed later.

The existence and wide distribution of metals of the platinum group, in veins, associated with ores of copper, is therefore well established.

That many such ores will be found to contain traces of platinum is almost certain, and the question of its recovery as a by-product, deserves a thorough investigation.

NATIVE METAL IN ERUPTIVE ROCKS

British Columbia.—During the summer of 1900, Prof. Kemp investigated the source of the platinum-gold placers of the Tula-

(1) Am. Jour. Sc., Feb., 1903.
(2) Eng. and Min. Jour., Sept. 16, 1893, p. 289.
(3) For some years the Vermilion mine has lain idle, and the extent and richness of these deposits were at first probably greatly overestimated.

meen River. A careful examination of the platinum showed that a considerable number of nuggets contained chromite. A few had particles of olivine adhering to them, and in one case pyroxene was found.

On the upper branches of a tributary of the Tulameen (Slate Creek), a large dyke of peridotite was discovered, flanked by pyroxenite. The peridotite is of the variety "dunite," and is made up almost exclusively of olivine and chromite, with small amounts of secondary serpentine. In its pure state, it consists practically of pure olivine with a little chromite. In the midst of the rock are found occasional veins of fibrous serpentine, which seem to have been formed from the peridotite itself along lines of minor dislocation.

The pyroxenite consists almost entirely of common green augite, with considerable magnetite.

The presence therefore of both olivine and pyroxene on the nuggets seemed to indicate that the platinum had been derived from both these rocks.

In his endeavor to trace the platinum back to its mother rock, Prof. Kemp. came to the conclusion that it must occur in some special form of the peridotite or pyroxenite.

As chromite was so frequently associated with the nuggets, it was natural to search for, and test masses of chromite in the rocks. These latter were practically confined to the veins of serpentine and the dykes of pyroxenite in the peridotite. Assays of the serpentine veins showed platinum in amounts varying from a trace to 2 oz. per ton, but it was found to be very irregularly distributed. Assays of the pyroxenite yielded only traces or none at all. No nuggets were found in place, so the platinum must exist as very fine scales.

Prof. Kemp also found traces of platinum in more or less decomposed portions of a granite, near the mouth of the Siwash Creek, another tributary of the Tulameen.

It is thus evident that platinum is *not confined to basic eruptives.* But whether the platinum has been introduced in solution or is an original constituent cannot be stated.

Russia.—Many attempts have been made to trace the platinum of the Russian placers back to their original source, but without definite success till quite recently.

In the Goroblagodat and Bisersk districts, platinum was detected in the bowlders of peridotite associated with the placers. From the association of syenite and gabbro bowlders with other deposits, Prof. Saytzeff concludes that platinum may also be present in them.

The most important discovery, however, has been that of Prof. Inostranzeff, in the Nischny-Tagilsk district, in 1892.

He recognized that the platinum came from Soloviev mountain, which consists largely of serpentines and peridotites. It was discovered that a laborer had been working by himself in the mountains, and had been following up a rock containing a small pocket. The part mined was a strongly altered and serpentinized olivine rock. It consisted largely of shattered serpentine, with chromite and dolomite, cemented by opaline silica. On crushing and washing it yielded extremely fine grains of platinum, and assays gave about 3 oz. to the ton.

Siberia.—Late investigations show that the mother rock of certain Siberian deposits is a variety containing diallage, but further particulars are not available.

Thus, while platinum has been traced with certainty to its source in a number of cases, it is noteworthy that it has always been found in connection with more or less altered or serpentinized rocks. This seems to indicate that the platinum has been concentrated to a great extent by secondary processes, probably in connection with the metamorphism of the rocks themselves.

The fact also that platinum has never been found in nuggets of appreciable size in the original rock, casts doubt on the probability of these larger masses being original constituents of the eruptive.

While it has not been directly proved, it seems most reasonable to assume that *platinum migrates in solution,* and under favorable conditions is concentrated in the form of nuggets.

From the relations of the chromite and olivine to the platinum, Prof. Kemp argues very strongly, for its primary nature. But as our knowledge of the chemical relations involved, and of the solution and precipitation, is so limited, a discussion of the matter at the present moment, would lead to no definite results.

Still the question is of such importance, that its further study will doubtless lead to the discovery of facts, which can be used to advantage in studying platinum deposits.

Experience already gained makes a number of points clear, however. That platinum is disseminated in the mother rock, especially those of the peridotite type, in small quantities, is satisfactorily proved. Prof. Kemp thinks that the chances of its being found in quantities sufficient to mine are not encouraging. But nevertheless there is a chance, and to that chance we must look.

To this end a more thorough investigation of peridotites and their concentrated decomposition products, is advisable, and may lead to important results.

Deposits of chromite and various copper ores likewise deserve attention, and should be tested systematically for small amounts of platinum.

ADDENDUM

Since writing the above, a case has come to my notice which proves definitely that platinum *does migrate* in solution. In a paper(1) read before the "Institution of Mining and Metallurgy," July 21st, 1904, L. Hundeshagen describes a deposit of wollastonite and grossularite, in Western Sumatra, containing platinum, gold, and a small amount of copper. The deposit, the author states, was originally a limestone lens, or bed, in the ancient schists. The limestone has been locally metamorphosed by apophyses of granite, into garnet and wollastonite, and *at the same time,* or *soon afterwards,* was mineralized by hot solutions, carrying platinum, gold, copper, etc. The platinum varies from

(1) "The Occurrence of Platinum in Wollastonite, on the Island of Sumatra, Netherlands, East Indies."

mere traces up to 12 grams per ton. The metal could not be detected by the microscope or by panning, though it was found in the concentrated river sands nearby in grains up to 0.30 mm. in diameter.

SEARCH FOR PLATINUM IN COPPER ORES

During the last few years, since the question of platinum in copper minerals has come into prominence, I have been carrying on a series of experiments with various ores which have been brought to my notice. These have been made with a double purpose in view; first, to determine the actual existence of metals of the platinum group, and second, to determine if the platinum occurred as sperrylite.

SUDBURY NICKEL-COPPER ORES

The existence of platinum in small quantities in the nickel-copper ores of the Sudbury district has been recognized for some time.

To see if it were generally distributed over this important area, I made a number of assays of the ore from different mines.

It was necessary to use rather large quantities, and samples of four assay tons (about 120 grams), were used for each assay. Pure ore as far as possible was selected, of different varieties. These included pure pyrrhotite, pure chalcopyrite, and a mixture of the two.

The ores were finely ground, the sulphur carefully roasted off, and a crucible fusion with lead oxide, made in the usual way. The lead buttons were then cupelled and the resulting "beads" examined for the precious metals.

Gold and silver were present in nearly all cases, the silver being much in excess.

The pure pyrrhotite yielded only minute traces of the precious metals, or none at all, thus confirming the view that they are principally associated with the copper.

The chalcopyrite from the Victoria Mine proved to be the richest, and a number of assays gave over 3 dwt. Pt. per ton, and one (pure chalcopyrite) as hign as 7 dwt.

Ores from Copper Cliff were somewhat poorer, and gave from 15 grains to 1 dwt. per ton.

Walker's assays of the matte from the Murray Mine indicate between 5 and 10 grains of platinum per ton.

Other metals of the platinum group are present, especially palladium, but these were not separately estimated.

The condition of the platinum in these ores still remained to be settled. From tneir vicinity to the Vermilion Mine, where sperrylite was discovered, it was quite commonly believed that the platinum existed as the arsenide in the unaltered ore, but it had never been demonstrated.

My experiments with the chalcopyrite from the Victoria Mine from which I succeeded in isolating sperrylite in perfectly fresh ore, have already been reported.

In further experiments, a number of samples of both pyrrhotite and chalcopyrite were also treated. In the pyrrhotite no traces whatever were found, while the residues from chalcopyrite from the Copper Cliff Mine gave a reaction for platinum, but I was unable to directly prove that sperrylite was present.

RAMBLER MINE, WYOMING

Shortly after Prof. Knight's announcement that the platinum metals existed in the copper ore of the Rambler Mine, Wy., Prof. Penfield isolated from it what he considered to be sperrylite(1).

Assays, however, show that the ore contains a much larger percentage of palladium than of platinum. At the request of Prof. Kemp I undertook the examination of some of this ore, which he placed at my disposal. The main object in view was to determine if the palladium were combined with arsenic in a manner similar to platinum. That a mineral with the composition PdAs might exist, seemed not improbable, and its isolation would have been a matter of universal interest.

The ores at my disposal were of several different kinds.

(1) Eng. and Min. Jour., Dec. 28, 1901. Am. Jour. Sc., Feb., 1902, p. 95.

(1) Oxidised surface ore, consisting largely of hematite, and hydrated iron oxide, with a siliceous gangue.

(2) Silicified and kaolinized rock, heavily impregnated with pyrite and chalcopyrite.

(3) Covellite, mixed with altered and kaolinized rock.

The ores were first concentrated to get rid of as much gangue material as possible, and then treated alternately with nitric and hydrofluoric acids, to destroy the sulphides and silicates respectively.

One thousand grams of the oxidised surface ore (No. 1) yielded no trace of a metallic residue whatever.

The residue from the second variety, of which another 1,000 grams were taken, contained 25 or 30 small brilliant, tin-white crystals and fragments, resembling sperryllite.

A third sample, consisting of nearly 3,000 grams of the covellite ore (No. 3), was similarly treated, and also yielded a residue containing a number of small shining crystals, together with some flakes of native gold.

The covellite is in all probability the result of a secondary enrichment, by downward moving waters, and therefore not the original home of the platinum metals. We must therefore consider that they were deposited primarily with the chalcopyrite and pyrite.

These experiments exhausted my available material. More than 5,000 grams were used and although I obtained a considerable number of minute crystals of the so-called sperrylite, the amount was much too small for a quantitative test.

As compared with Sudbury sperrylite, the Rambler mineral is very similar outwardly. The crystals are however much smaller, and do not appear to be so well developed crystallographically.

The above results are in many respects unsatisfactory, but the determination of a natural compound of palladium with a non-metallic element, would be a matter of great scientific interest, and it is the writer's hope that, with a sufficient amount of ore to work on, a definite result may be obtained.

COPPER ORE FROM ROSSLAND, B.C.

A number of samples of copper-pyrites from the Le Roy No. 2 mine, Rossland, B.C., have been examined for platinum and sperrylite. The residues contained small flakes of native gold, but no traces of platinum or sperrylite could be detected.

PLATINUM IN THE COPPER ORES OF THE KEY WEST MINE, BUNKERVILLE, NEVADA

In June, 1903, I received from Prof. Kemp, of Columbia University, a small piece of copper ore, weighing about 150 grams, from the Key West Mine, Bunkerville, S.W. Nevada. The ore is chalcopyrite which occurs in a hornblende granite, in close association with a peridotite dyke. The ore is intimately mixed through the granitic rock, and the sample in my possession contained only about 65 to 75 grams of chalcopyrite. It was difficult to separate the ore from the rock minerals by mechanical means, because of the danger of losing part of the sulphides. So the original crude ore was used for the experiments. Assays have proved conclusively that the chalcopyrite contains metals of the platinum group, and the next step was to determine if the platinum existed as sperrylite.

The ore was coarsely crushed and the sulphides decomposed by repeated treatment with nitric acid. As sulphur separated this was removed by means of boiling caustic soda. The quartz and silicates were then destroyed by treating a number of times with hydrofluoric acid. The final residue was found to consist of small prismatic crystals and grains of zircon, but not the least trace of a metallic looking mineral could be found(1).

In October, 1903, I obtained another sample of ore from the same mine, from Prof. Kemp. The ore was quite similar to the previous sample, except that part of it contained a considerable amount of a secondary talcose mineral, and showed the effects of shearing.

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(1) These experiments were carried on in the laboratory of the School of Mining, Kingston.

In all there were some 450 grams, of which about 200 to 225 grams were chalcopyrite with a little pyrite.

The ore was coarsely crushed and treated as before.

But although every care was taken to prevent mechanical loss, no trace of insoluble metallic particles remained. Small zircon crystals as before constituted the entire residue.

It seems therefore clear that platinum *does not* exist as sperrylite in this ore.

In what form it is present, it is impossible to say, as the freedom of the zircon residue from anything of a metallic nature, leaves nothing on which to base a deduction(1).

PLATINUM IN NORWEGIAN NICKEL-COPPER ORES

Prof. Vogt, of Kristiania, Norway, sums up the facts regarding the precious metals in the Norwegian nickel-copper ores, in a recent paper(2).

Silver, platinum, and gold are present in small quantities, the silver being in excess of both platinum and gold, and platinum in excess of the gold.

In a private communication, Prof. Vogt informs me that the highest platinum results are obtained from chalcopyrite, which agrees with the relations at Sudbury. A number of analyses of the Norwegian matte (containing 45—50 per cent Ni.) gave 3 grams of platinum per ton. The average ore which goes to the smelter, contains about 2.50 per cent. Ni., so that the ore contains on an average about 0.17 grams Pt. per ton. The amount is certainly very small, and even in the chalcopyrite, where it is concentrated, it cannot be large.

Prof. Vogt believes that the platinum is present as the arsenide, as in Sudbury, but as yet no one has been able to demonstrate this.

Through the kindness of Prof. Vogt, I was enabled to secure a couple of samples of both chalcopyrite and pyrrhotite from the

(1) These experiments were carried on in Heidelberg, in the chemical laboratory of Prof. Dittrich.

(2) Zeit. für prakt., Geol., 1902, pp. 258-260.

Flaat Mine, Evje, Norway. In this I endeavored to determine the condition of the platinum.

The ore consisted of chalcopyrite and pyrrhotite, mixed through a uralitized grabbo, sometimes one sulphide, sometimes the other, being in excess.

I selected a piece consisting largely of chalcopyrite, and weighing about 1,500 grams. Of this about 400 grams were pyrrhotite, 300 rock, and 800 chalcopyrite.

The ore was coarsely crushed, and treated in large evaporating dishes, with nitric acid, till most of the sulphides were dissolved, occasionally removing the separated sulphur by means of caustic soda. It was then possible to remove a large quantity of feldspar and hornblende by washing, without danger of losing the ore minerals. The rest of the sulphides were then dissolved and the remaining silicates decomposed by means of a number of treatments with hydrofluoric and sulphuric acids.

The final residue consisted of small crystals and grains of zircon, among which could be recognized with the naked eye, several flakes of *native gold.* No other metallic grains could be detected with certainty, even by means of the microscope.

A portion of the residue I submitted to Prof. Kolbeck of the Bergakademie, Freiberg, for examination. By making a careful blowpipe assay, Prof. Kolbeck was able to detect platinum in the residue. This minute quantity was, however, likely derived from the platinum vessel used in the last stages of the concentration. Another portion of the concentrate was treated with aqua-regia, the residue was fused with sodium carbonate and sulphur to insure the decomposition of sperrylite if present. A careful search was then made for arsenic, by Marsh's test, but not the least trace could be detected(1).

In the fall of 1904, I received from Mr. F. Henriksen, Director of the Evje Nickel Co., Norway, another collection of samples of copper-nickel ores from the Flaat Mine.

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(1) These experiments were made in Heidelberg and Freiberg, Germany.

Part of the ore consisted of practically pure chalcopyrite, and I undertook the formidable task of treating some 5,000 grams of this material, in order to examine the insoluble residue(1).

The ore as before contained a small amount of pyrrhotite, and fragments of the uralitized-gabbro gangue.

After decomposing the larger part of the sulphides with nitric acid, most of the rock minerals were removed by panning, and the rest destroyed by hydrofluoric and sulphuric acids.

The final residue weighed less than half a gram, and consisted largely of small zircon crystals, and a black mineral which was not identified with certainty.

Among the non-metallic grains, ten or twelve small flakes of *native gold* were plainly visible to the naked eye. But as in the former experiment with these ores, not the slightest trace of a mineral resembling sperrylite or native platinum could be detected.

As sperrylite is absolutely insoluble in nitric, and hydrofluoric acids, there is only one possible conclusion to draw from these experiments, viz.: *that platinum does not exist as sperrylite in the Norwegian nickel-copper ores.*

A total of nearly 8,000 grams of the ore richest in platinum (the chalcopyrite) was treated, with all precautions, to guard against mechanical loss, and if sperrylite had existed, even in minute crystals, its recognition would have been certain.

Assays of the ore prove that platinum is in excess of the gold, yet the latter was found in the residue, while no trace of the former was visible, either in the metallic state or as the arsenide.

To the extent, therefore, of proving the absence of sperrylite, the experimental results are positive. But as to the actual condition of the platinum they are negative.

At present no suggestions on this point can be offered, and the interesting question, as to the form in which platinum exists in the Norwegian nickel-copper ores, so similar in other respects to those of Sudbury, is left open.

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(1) Experiments carried on in the chemical laboratory of the School of Mining, Kingston.

In conclusion the writer wishes to express his thanks to Prof. Vogt, of Kristiania, and Mr. F. Henriksen, Kristianssand, Norway; and to Prof. Kolbeck, Freiberg, for assistance in this investigation.

DISCUSSION.

Dr. Dickson.—Platinum has been creating a good deal of interest, and a number of important papers have been issued on the subject. Prof. Kemp, of Columbia, has published a paper in which he deals with the sources of platinum in the mother rock. While I was revising my paper I received a paper from our own Geological Survey, on the same subject.

Dr. Goodwin.—Dr. Dickson has brought out an important point in his favor, namely:—the necessity for increasing our output of platinum in the world, and I, as a chemist, appreciate that necessity very strongly indeed. I should wish to refer to one more point: platinum from the Vermilion mine. I think that, judging from the information that I have obtained from time to time, we may hope that this mine will yield a considerable quantity of platinum, and there should be in that district other places in which the platinum has been concentrated. When we remember that platinum is a fairly constant constituent of our nickel ores there, and when we remember how widespread these ores are, I think we may hope that in some places platinum has been concentrated, and when prospecting has progressed far enough, a considerable addition to our stock of platinum may be produced in this section.

Mr. J. W. Evans.—One point I notice in Dr. Dickson's paper, in reference to the Vermilion mine, I don't agree with him when he says that Mr. Brown's estimate of 15 oz. of platinum per ton in the decomposed ore is too high. When I was at the mine, the caretaker there showed me a quart flask filled with spyrilite, and the amount of ore he treated to get this quantity could not have been large. I think that 15 oz. per ton would not be too high an estimate for the quantity contained in the decomposed ore. I had a conversation with the care-

taker on this matter, and he told me that he could take me to some spot where the sperrylite could be found in great quantity. This, of course, was in the decomposed ore.

Dr. Walker.—I have been at the Vermilion mine, and my impression is that the platinum, any place where I tried for it, was not so abundant. I have seen the bottle of sperrylite, and at various times I have endeavored to secure a little of it. From the high price, however, demanded of me, one would imagine that it was a very difficult substance to obtain. There was considerable proportion of platinum associated with the gold, found south of the St. Lawrence and Quebec, thirty or forty years ago, when this region produced considerable quantities of platinum. It is desirable for this Institute to do what it can to encourage such investigations as Dr. Dickson has brought before us. If it were possible, a fund should be raised, so that we could interest ourselves in a practical way. The Royal Society of England uses such funds with great advantage for scientific research.

Dr. Dickson.—The point to which Dr. Walker refers, in reference to the discovery of platinum at Quebec, has been mentioned in the recent paper of the Geological Survey, so I did not think it necessary to incorporate that information in my paper.

Mr. Gibson.—Dr. Dickson refers to the nickel-copper ores of the Sudbury district as a source of platinum. It has, of course, long been known that platinum occurs in small percentages in these ores, but it is not so generally known that during the last two or three years a considerable quantity of platinum has actually been recovered in treating them, and, in addition, about an equal quantity of palladium. The outlook for obtaining further supplies of these metals from the Sudbury ores is, I understand, not very promising. The production is made from the mattes of the Canadian Copper Company, which are refined in New Jersey by the Orford Copper Company. Formerly, most of the ore smelted by the Canadian Copper Company was derived from the Copper Cliff and neighboring mines, which are much richer in platinum

and palladium than the ore of the Creighton mine, six or seven miles to the west, whence the company now derives the great bulk of its ore. In fact, I am informed the production has in the meantime been suspended.

Dr. Barlow.—The investigations, undertaken by Dr. Dickson, were conducted in the same area in which much of my work has been done, and I have taken a great deal of interest in the matter. We have tried to get some authoritative statement with regard to these platinum ores, but information has not been given out as readily as it might have been. The first return made by Mr. Ingall was made from the report which I recently wrote and distributed many members of this Institute. We made an estimate of the platinum, and all the constituents of the ore, and I believe that estimate was a fairly correct one.

Dr. Dickson.—I would like to ask Mr. Gibson whether this product is credited as coming from Canada or from the United States when it is concentrated and refined?

Mr. Gibson.—Up to the present time, it has not been credited to any source, for the fact of production was not made known. The production, of course, belongs to Ontario, and should be so credited.

Dr. Barlow.—Is there any statement made of these products of platinum?

Mr. Gibson.—I have the returns at Toronto, but did not bring them with me. I would not like to give the figures from memory. I may say I did not receive the information under any seal of secrecy, and the statistics will be published in the forthcoming report of the Bureau of Mines along with the other official statistics of the mining industry of Ontario. The statement that palladium was being recovered from the Canadian Copper Company's mattes was made in an address delivered by Dr. Joseph Wharton, who is connected with the Orford Copper Company, before the American Philosophical Society in April last. Dr. Wharton attributed to the Company a production of 3,000 ounces of palladium annually from approximately 300,000 tons of Sudbury ore. This fact being

made public, the company was invited to furnish the figures of production respecting the other bye-products of the matte, and they readily responded by giving the statistics not only for 1904 but also for 1902 and 1903, or practically since the production had begun, and covering not only palladium, but platinum, cobalt, gold and silver as well. I am sorry I have not the figures here, or I would give them, since they demonstrate beyond doubt that the nickel-ores of Ontario contain appreciable and recoverable percentages of these precious metals. Cobalt was obtained a number of years ago from the mattes of the Dominion Mineral Company, but the Canadian Copper Company had never previously acknowledged the recovery of anything but nickel and copper. The statement was made by the officials of the Orford Copper Company, and no doubt with truth, that if the mattes had to be treated for the cobalt and precious metals only, the undertaking would not be a profitable one, but while conducting the processes necessary to obtain the nickel and copper, they are enabled at the same time to separate the cobalt, platinum, palladium, gold and silver. Owing to the ores now smelted by the Canadian Copper Company coming almost wholly from the Creighton mine, which are very high in nickel, fairly rich in copper, but poor in platinum and palladium, it is understood the production of the latter metals, as well as gold and silver, has ceased. As to cobalt, since the company's new smelting plant at Copper Cliff has gone into operation, the matte product is almost wanting in this metal, since in the bessemerizing process it oxidizes very quickly and passes off with the iron, the nickel remaining behind. The result is that the cobalt is now being lost, and this source of supply will be cut off.

Mr. Ingall.—I have also the figures of production, but in the past we have had to keep figures of that kind to ourselves, because the operators refuse to let us publish them.

Mr. Coste.—We have had a very valuable paper and a very interesting discussion following it. There was a point that Dr. Dickson referred to which is interesting in connection with platinum, viz., that it was connected with acidic igneous

rocks. We had the same connection of copper with acidic rocks in very many parts of British Columbia pointed out in the paper of Mr. Brewer's, yesterday. He pointed out that a great many of the copper deposits there were in connection with felsite, so we seem to have the same connection with regard to platinum, and it is natural therefore that the two minerals, copper and platinum, should also be connected in some deposits.

I tender a hearty vote of thanks to Dr. Dickson for his valuable paper. That was a very good suggestion that was made by Dr. Walker that the Institute might possibly contribute to original researches such as this one by Dr. Dickson. I no not see anything impossible in that, in fact, I do think that there is nothing in reason impossible for the Canadian Mining Institute. We are not exactly rich, but we are doing very well, and we may do better in a year or two, and we might consider the question favorably, I think. Many of the members would be glad to do it. It is a good suggestion.

Mr. T. T. Read (Fellow in Mining, Columbia University)—In the case of the Rambler mine mentioned, the sperrylite is undoubtedly associated with the chalcopyrite which, although its concentration into an ore body is most probably secondary, is an original constituent of the eruptive rock. Whether the spyrilite is also original or secondary is not yet known, although the former seems most probable. The occurrence described by Hundeshagen is quite exceptional, apparently.

In regard to the negative results obtained by Dr. Dickson, I have already pointed out (Eng. & Min. Jour., May 25, 1905) the necessity of the greatest care to prevent mechanical loss of small crystals when this method of separation is followed. Since Dr. Dickson also observed this, apparently the suggestion of mechanical loss does not apply. The results might have been checked by filtering the solution and assaying the filtrate for platinum. This operation in the case of the Rambler ore showed that none of the platinum had gone into solution.

BANKHEAD COAL MINES.

By C. M. Henretta.

These mines are operated by the Pacific Coal Company, Limited, under a lease from the Dominion Government. They are located five miles from Banff, and inside the Rocky Mountains Park. The coal measures were known twenty years ago, and some prospectors set to work about four miles north of the present mine location. After exposing several coal seams they abandoned their work, and nothing more was done until late in the summer of 1902, when the work was taken up by the Canadian Pacific Railway Co., and at the close of that season sufficient work had been done to justify further prospecting in 1903. Work was started again in May, and by July of that year the coal seams had been traced southward, and openings started on the two bottom seams.

The coal measures belong to the Cretaceous age, and through the upheaval of the lower limestone formations the heat created changed the character of the coal, and the two, possibly the three, lower seams were changed from a semi-bituminous coal to semi-anthracite coal. The formation was raised upwards on the eastern side, and the coal seams now dip to the westward at an angle of about 50 degrees. This is measured in places where the local disturbances occurred. to even 90 degrees. It was first considered to be all semi-anthracite coal, but later developments prove that the southern half of the field, on the lower seams, is semi-anthracite coal and the northern half of the lower seams is a semi-bituminous coal. All the top seams are semi-bituminous, and, in fact, most of the coal will be found to be semi-bituminous. Nothing definite is known as to the number of seams and their thicknesses. In places where cross-sections were made, as many as ten seams were found, but it is safe to say that about six or seven workable seams will be found. The coal seams ex-

tend northward from the present mine openings for about five miles, where they are cut off by the limestone formation.

A tunnel, or gangway, has been driven in on No. 1 seam for about 1,600 feet, and on No. 2 seam for about 2,300 feet. These are driven on a one-half per cent. grade, with a water ditch along one side. The coal is taken out the full width of the seam and for eight feet up on the foot-walk, above track level. The high rib is sheered off, and heavy props set at right angles to the seam, five feet apart, and 4-inch logging placed behind the props to hold the coal in position. At a distance of about 800 feet from the mine opening, an air chute, twelve feet wide, was driven up the pitch on the two seams to the surface, a distance of nearly 300 feet, and these connected on the surface with a box, and a 10-foot ventilating fan exhausts from both seams. This fan is now running with an electric motor.

The coal is of a soft, friable nature, and has a tendency to run in places, therefore it was thought to be safer to leave thick pillars. The main pillar above the gangways is sixty feet thick. From the air chute on both seams, counter or return airways were driven, and these are about the size of the main gangways.

The coal in neither seam amounted to much until a distance of over 500 feet had been driven, at which point there are over 150 feet of cover over the coal. The No. 1 seam has an average thickness of about nine feet, with the bottom half of the seam very soft, friable coal; the upper half is fairly hard coal, but far from being a good coal. No coal had been shipped from this seam, only that made in development, as it was not considered good. The chances are that the seam will not improve much, as it should have been good now, where the surface is regular and plenty of cover over the coal. No. 2 seam has an average thickness of about eight feet, and, in general, consists of fairly good coal, although very friable, and produces a great amount of small coal. Nearly all the coal shipped has come from No. 2 seam. The system of mining

in No. 2 secured a large percentage of the coal, and was the safest method to use; and when the statement is made, that from the opening of the mines up to the present time not one serious accident has occurred, it reflects much credit to those in charge of the work.

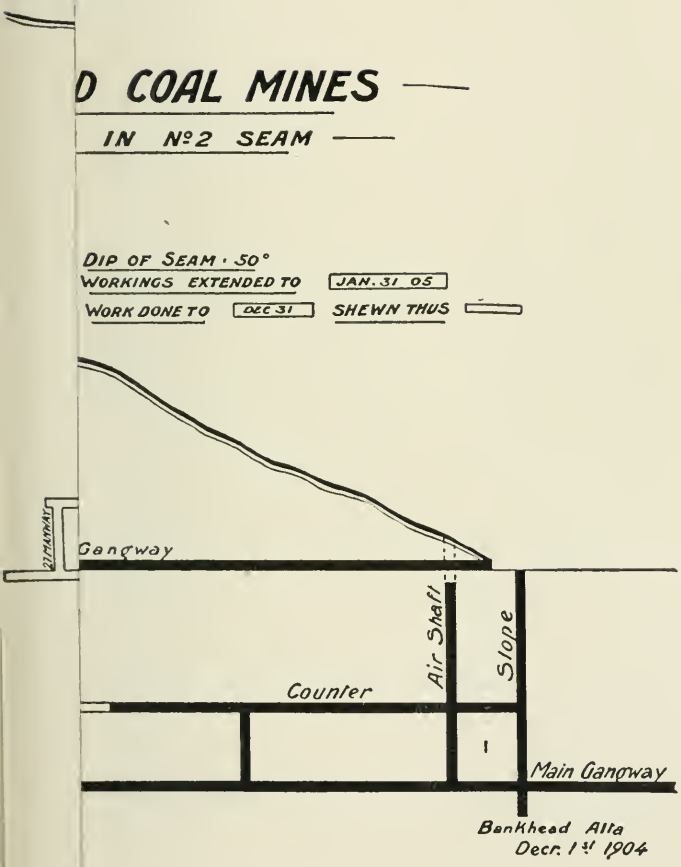
From the main gangway or haulageway in No. 2 seam, chutes were driven, ten feet wide, up to the counter gangway, which is sixty feet above. These chutes were driven every sixty feet, which left fifty feet of solid pillar between them. Manways, eight feet wide, were driven between every fourth chute, and these were driven straight up the pitch to the last cross-cut. A timber chute was put in each manway, and all timber was hoisted up on a skip and delivered to the different working places. A small compressed air hoist was mounted on a truck and pushed back or forth along the gangway to the different places used for hoisting timber.

At the bottom of the coal chutes, at proper height above the mine cars, suitable stoplings were put in to handle the coal at will, and all coal loaded from the chutes into the cars direct. To load a trip of two ton cars requires about two minutes for each car. The chutes are kept full of coal up to the counter gangway, where a bulkhead is put in to permit of travelling along the counter. Above the bulkhead the chute is widened out at both sides from ten feet to twenty-four feet. Props are set three feet from each side and 1½-inch plank nailed on these to hold the coal, which makes a chute eighteen feet wide. Ladders are placed on the foot-walk on each side of the chute to travel on. The miners kept the chute full of coal, only advising drivers to take away the loose coal when the chute gets too full to work in to advantage. The coal is knocked down by thirty per cent. giant powder, and with three shots about twenty tons of coal will be mined. The coal is shot out of the solid in all gangways and up the pitch. It is drawn out of the chutes into the mine cars, and hauled to the breaker where it is screened and sized over shaking screens. At present the different-sized coals are—

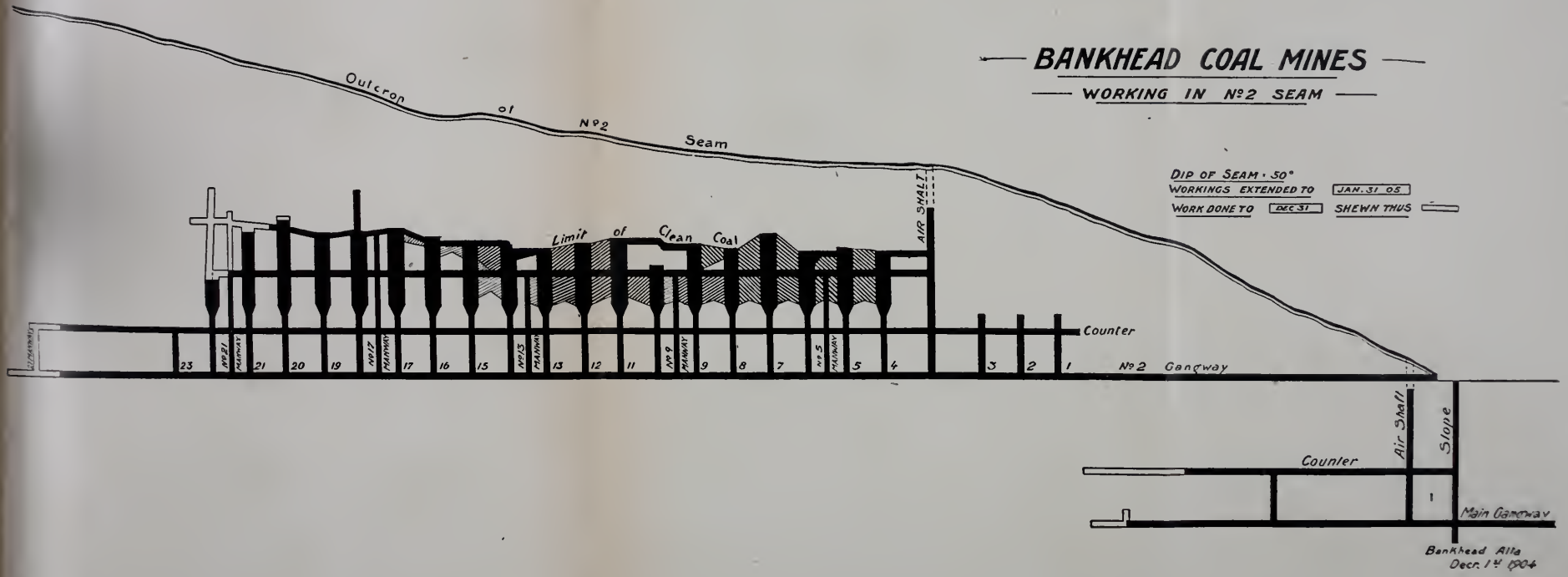
lump, egg, stove, nut, pea, and No. 1 buckwheat. The two smaller sizes will be used for steaming purposes. The coal is very friable, and in the handling it makes a large percentage of small coal. The lump, egg, stove and nut run about thirty-five per cent., and with the pea and No. 1 buckwheat the percentage may run up to about sixty per cent. An attempt may be made later on to use the No. 2 buckwheat, possibly No. 3 grade, but this will require some time. Possibly a briquetting plant will be installed, but the latter is far in the future. Some analysis of the coal run very high in fixed carbon, but the average is about ½ per cent. moisture, 8 per cent. ash, 9½ per cent. volatile matter and 82 per cent. fixed carbon. It burns with a pale blue flame, and is smokeless. The semi-bituminous coal will run more in volatile matter and lower in fixed carbon, and burns with a yellowish flame, and has a slight tendency to coke, and smokes somewhat. No estimate has been made as to the probable tonnage in the property, as the number and thickness of all the seams is not known, nor to what depth the seams continue below the present openings.

The original openings on Nos. 1 and 2 seams are at an elevation of nearly 200 feet above the level of Cascade River, and the grade on the railway to the mines would have been about two per cent., so as to avoid such heavy grades the mine spur was located along the river bottoms, and to reach the coal it required either an incline tramway or a long tunnel —the tunnel was decided on, and was begun in May and completed in December. It was excavated eleven feet by twenty-four feet, and square-settled every five feet with 12-in by 14-in. posts and 14-in by 16-in. collars, with two rows of posts near the counter. A mud sill was used, and the top and sides lagged with 3-in. plank. It is double-tracked, with travelling-way in the centre for men and animals. The first 1,100 feet was in gravel and last 200 feet in rock, slates and coal. It was driven very rapidly, and cost a large sum of money. This tunnel will be the main haulage way, and it taps the coal seams 189 feet below the original openings, and 234 feet measured on the pitch of the seams. A rock cross-cut, with

its parallel for air, will be driven across the measures, and



not in existence at all; boarding houses are run by individuals


BANKHEAD COAL MINES
WORKING IN Nº2 SEAM
Outcrop of Nº2 Seam
DIP OF SEAM · 50°
WORKINGS EXTENDED TO JAN. 31 05
WORK DONE TO DEC 31 SHEWN THUS
AIR SHAFT
Limit of Clean Coal
Counter
Nº2 Gangway
23
Nº21 MAINWAY
21
20
19
Nº17 MAINWAY
17
16
15
Nº13 MAINWAY
13
12
11
Nº9 MAINWAY
9
8
7
Nº5 MAINWAY
5
4
3
2
1
Counter
Air Shaft
Slope
Main Gangway
Bankhead Alta
Decr. 1st 1904

its parallel for air, will be driven across the measures, and this will tap all the seams of coal. The coal from the upper levels will be dropped down to the large tunnel on twenty degree inclines, and will be hauled out to the breaker by compressed air locomotives.

The style and size of the large breaker for handling the coal has not been determined, nor the scheme for hoisting the coal to the top of the breaker. The coal will have to be run up in the pit cars and dumped on top, which will require heavy and expensive machinery. The capacity of the mine will depend on the market. The plant throughout is certainly equipped with the best of machinery; and the shops, etc., are large, well-lighted, and capable of handling much larger mines than is expected at Bankhead. An up-to-date electric plant is nearly installed, and all the buildings, including all houses in the town, will be supplied with electric lights, and Banff will also be supplied with both house and street lights.

The town of Bankhead is a model in itself, and is nicely located. All the houses in the town will be connected with a water system, which gets its supply from the pure mountain waters of the Cascade River. An up-to-date sewer system has been put in, and every house will be supplied with baths, etc. Twelve of the more expensive houses are supplied with hot-air furnaces, etc. One of the neatest and most attractive general offices to be seen in the west is located here, and a large general store carries a line of goods equal to many cities of five times the population of Bankhead. A large hall is used for school, churches, etc., until the coming summer, when a large school and different churches may be built. The town will soon have one of the finest brass bands in the west, and, although not one year old yet, can claim a population of over 600 people, and numbers among its amusements curling, hockey, skating, tennis, football, baseball, and even a dancing club. The policy of the company has been to allow no hotels with saloons in connection, and it will be a great source of regret if this idea is not carried out. The company store is not in existence at all; boarding houses are run by individuals

who pay a certain rent for same. The coal company controls all the ground available for building purposes, and no lots are leased or sold. It is difficult to predict the probable growth of Bankhead, but it will possibly have a population of 2,000 people inside of five years.

THE STRATIGRAPHY OF THE CASCADE COAL BASIN.

By D. B. Dowling.

Previous to the uplift of the Rocky Mountains all that part of the continent had for ages suffered but little from earth movements except, perhaps, a shallowing of the sea from Carboniferous times. There is little if any deposit to mark the lapse of time between the Carboniferous and the earlier stages of the Cretaceous, but the succession of the beds indicate no physical break. During most of the Cretaceous time the sea does not seem to have maintained any great depth, but shallow water conditions are marked at its inauguration, at about the middle period and again toward the close. This was followed by fresh water inundations, probably in the form of large lakes in which were deposited the Tertiary beds of Alberta.

The shallow water periods of the Cretaceous also show intervals of emergence during which land conditions prevailed and vegetation flourished. As the elevation of the land was not greatly above the sea, frequent inundations followed and the vegetation was covered up to be gradually changed to coal beds. We have thus three horizons that can be considered coal bearing in the Cretaceous.

1. The lower part of the formation—called the Kootenay series. Typical sections of this are given in the Crow's Nest Pass, as well as in several of the Rocky Mountain coal areas and in the Queen Charlotte Islands.
2. The middle portion of the formation—The Belly River series. This is exposed between Lethbridge and Medicine Hat, on the Belly River, and on the Peace River near Dunvegan. To this we may refer probably some of the seams that are exposed in the foothills near the outer range of the mountains.

Prospective of model of Cascade and Bow Valleys, looking about N.N.W. It shows the Bow River from below Canmore up to Banff, and also a part of Cascade River. The coal-bearing rocks occupy a somewhat narrow belt along the western part near the centre of the valley. The topography is obscured a trifle by the geological coloring.

3. The upper part of the Cretaceous—the Lignite Tertiary of early nomenclature. In Northern Alberta this is now known as the Edmonton series and it probably is continued south as the St. Mary River beds.

This last division furnishes coal over a large area reaching from Manitoba to near the mountains. In Manitoba these rocks occupy the summit of Turtle Mountain in the south. In Assiniboia, or the new Province Saskatchewan, they underlie portions of the Cypress Hills and cap Wood Mountain and the Coteau, and occupy a shallow syncline eastward through which the valley of the Souris is cut and from which much of the lignite consumed in the eastern section is obtained.

The one with which we are at present interested is that first mentioned—the lower part of the Cretaceous, the Kootenay series, as it contains the most ancient and therefore, we might say, the best quality of coal. It owes its exposure here altogether to the uplift of the Rocky Mountains and is found to the west of the outer break of the range. This outer break has been of such dimensions that the uplifted beds on the west exposed the lower rocks as low down in the series as the Cambrian, and these latter rocks are found thrust up over those of the middle Cretaceous to the east of the fault. At the gap of the Ghost River, Mr. McConnell observed an overthrust of over two miles, and estimates the total there to be nearly seven.

A rough diagram of the section as observed at the Bow River Gap from near Cochrane to the valley of the Spray River, will help to place before the eye the disposition of the beds after the various fractures. The amount of displacement of the outer fault is conjectural in so far as concerns the thickness of the lower portion of the Cretaceous. Faint lines to show the amount of eroded material are added, but it must be remembered that the breaks which are so sharp through the limestones probably when continued upward through the softer rocks vary much in character and were compounded or even ran into folds before reaching the sur-

Three blocks of the model in perspective to show structure of the field northward from Bankhead. Coal seams are indicated by broken lines.

face. The original surface line would probably represent the section of an undulating elevated plateau.

The general elevation here has been much greater than farther south in the vicinity of the Crow's Nest Pass and the denudation consequently of a more pronounced nature, so that remnants only of the softer rocks above the limestones are left in the broader longitudinal valleys. The section will also help to illustrate what is meant in such a statement as —If a few thousand feet less of these rocks had been swept away, we would have here what would compare, very favourably, for a coal producing area, with that at Blairmore and Frank. The section across the measures at the latter place to the north of Grassy Mountain resembles very much one drawn here, about three thousand feet higher than the present surface.

The preliminary study of the rocks of the Cascade basin, which is here the first and most prominent of the remnants of the Kootenay rocks inside the first range, led Dr. Dawson to speak of it as a basin or trough. This is true for a small portion of the area near its northern end, but for the major part, the break at the west is of the nature of a fault, and much of the coal producing rocks have been overridden by the rocks thrust up from the west.

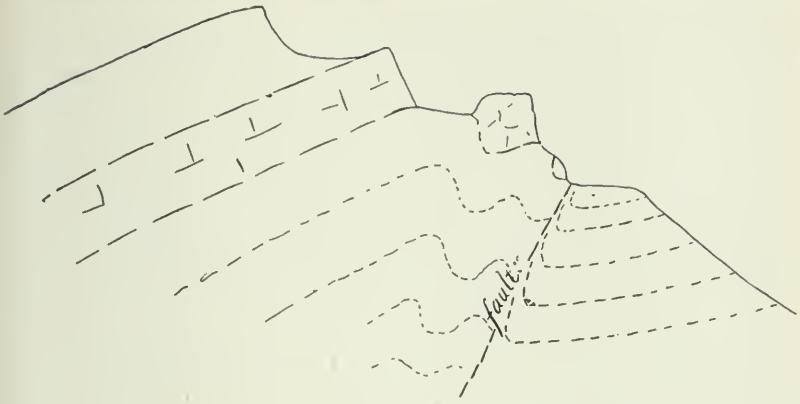
A study of this break shows that the primary folds did not attain such great dimensions as are generally given for mountain structure, but were rapidly sharpened up and the break in the limestones was attended by little folding. The upper members of the series thus affected have since been removed, so that a study of the complete fault line is impossible. The general line followed by the fault apparently is near the crest of the anticline. In the Cascade basin, however, there is an example of the break leaving one fold and running to another. At least the deflection in the general line of the fault would look somewhat like this, as the continuation of the fault line from the Kananaskis along the front of the Rundle range would strike near the centre of Cascade Mountain where there is distinctly showing on the face of the

mountain an anticlinal fold, and its continuation along part of the Rundle range has been traced. This has been figured by Dr. Dawson as proof of the complete downturn of the limestones beneath the Cretaceous trough, but there is room for but a small portion of the beds.

Northward of Cascade Mountain the break gradually changes to a fold with perhaps a small break in the beds between the crown of the anticline and the bottom of the syncline. The hills forming the continuation of the Cascade Mountain are anticlinal ridges with a trough of Cretaceous along either margin.

South of the Kananaskis river the Cretaceous beds dip to the southwest and run under the limestones brought up by the fault. On the height-of-land, between this stream and the Bow, the slope of the beds becomes less and very little of the coal-bearing rocks seem to have been over-ridden, and the limestones abut directly against the ends of the beds. They have in consequence sustained a severe pressure, and the lateral movement of the mass has been taken up by a series of flexures in both the limestones and the coal-bearing sandstones. The former are crumpled in a series of waves running nearly parallel to the fault line by which the beds away from the fault become more elevated in a series of steps. This can be seen in the peaks called the Three Sisters—three peaks in line back from the fault, at successively higher elevations. The lower and more easterly one is a remnant of a syncline in the beds which form the centre one. These folds continue south to the foot of Wind Mountain, and seem to pass beneath it and may continue still farther.

In the Cretaceous in front of this part the beds are not very much disturbed, except near the contact, where they are crumpled and seem to be brushed up along the fault line. These comparatively disturbed beds occupy a partly dissected plateau south of the Three Sisters and on the height-of-land to the Kananaskis, a strong fold is seen to accompany the change to the monocline structure. This is well marked in the upper beds, which are coarse sandstones and conglomer-



Section at Three Sisters Peaks

ates, and the fold is seen to run from near the fault line north of Wind Mountain, southeastward, on a line which carries it gradually higher and away from the fault. In the lower beds of the series it is thought that the fold will be less marked, and in the angle contained between the fold and the fault, there is probably a sharp anticline. Northward from here to the Cascade Mountain, the Cretaceous is overlapped by the limestone from the west, but a series of flexures in the coal-bearing measures are found in the Canmore mines, which are probably continued along in front of Rundle Mountain, and seem to indicate that the direction of pressure was not at right angles to the fault, but more from the west. As the sliding of the limestone was upward along the fault, a series of waves in the coal seams might have been expected running parallel to the fault and not far from horizontal. Those found, however, have a pitch downward toward the south. A possible explanation may be deduced from the fact that the fault line in the vicinity of Anthracite is deflected to the north and then gradually dies out or is changed into a fold with less displacement. This gives us then a pivotal point on which a large block can be assumed to have swung. This

would allow of a sliding of the limestones upward in a direction at right angles to the direction of the folds.

The part of the field thus affected extends from between Canmore and Anthracite southeastward to the foot of the hill below the Three Sisters. The beds east of a line running north and south through the town of Canmore are not much disturbed. To the west of this line they dip downward and pass through a series of waves as already noticed. At Anthracite the seams do not appear to have been affected by this series of small waves, but there is instead a much larger fold pitching downward in nearly the same general direction but at an easier angle. Mining operations commenced here on the beds dipping down into this fold, and on account of the great denudation in the valley of the Cascade River at this point the beds could not be safely followed down through the trough and over the saddle on the far side, without running into the water-laden gravel of the river. In the northern part of the mine, where the trough was shallower, the western

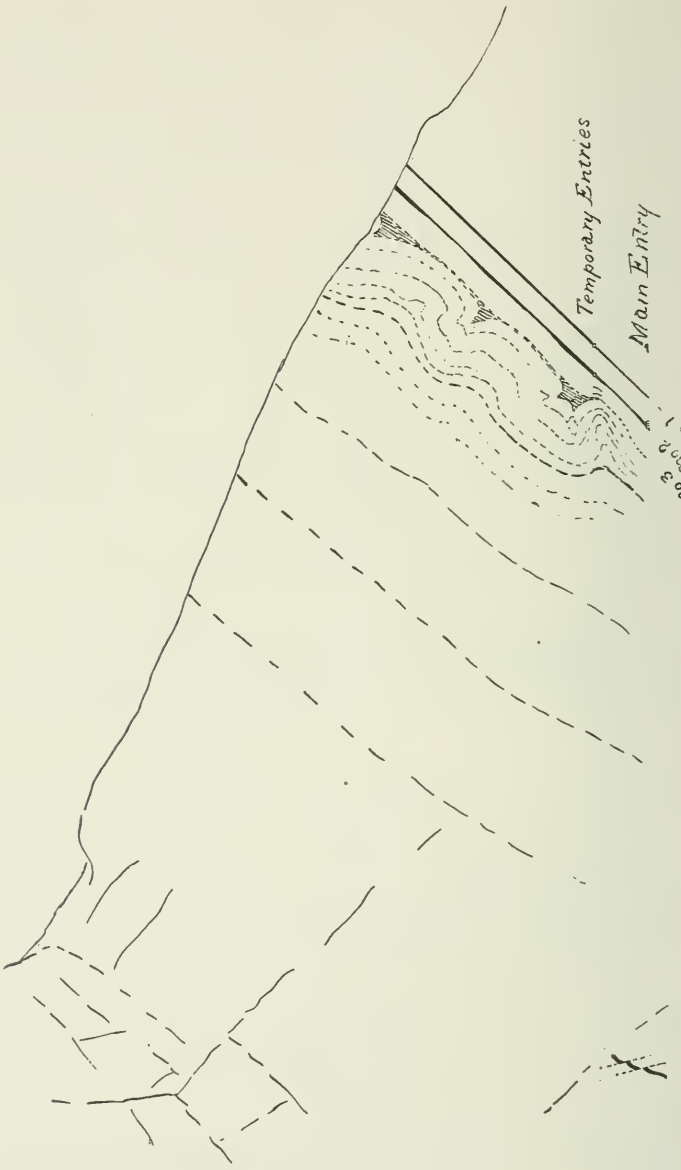
SKETCHES OF THE CRETACEOUS PLATEAU BETWEEN THE BOW AND THE KANANASKIS RIVERS.

The upper one is looking across the valley of the Kananaskis southward, and shows the coal-bearing beds dipping beneath the limestone. The foreground in each shows the limestone abutting against the Cretaceous, forming a fold in the latter by the pressure.

upturn showed a slight bending toward the west, and this if it could have been followed far enough, would have led downward into the seams in the rest of the property. The sandstones below the coal can be traced northward to cross the Cascade River, and it seems rational to suppose that the coal seams above should do the same. The mining operations were continued only long enough to extract the coal from the seams within the fold, and little prospecting was done on the northern and larger part of the property. That the seams continued north past the fold is abundantly proven in the prospecting done on the measures north of the Cascade River by the C. P. Ry. The strike of the beds changes after passing Anthracite, but remain fairly constant for about five miles from the crossing of the Cascade, with a general dip to the west of 45 deg. or 50 deg., but here the beginning of a shallow syncline is found, and before the end of the Cascade Mountain ridge is reached the coal-bearing beds run into the fault line. As the valley of the Cascade River narrows up, less of the Cretaceous rocks remain, and at the northern end only the dark shales below the coal-bearing measures are left. As the whole of this area is taken up by the C.P.R., it is intended to work it all from the south end, following the seams on an entry but little above the Cascade River.

The southern end of this field consists of a monoclinal block of Cretaceous dipping to the west, partly over-ridden by the limestone of Cascade Mountain. This overthrust has made some impression on the rocks composing the block. The two lower seams on which work is progressing now are well protected by heavy beds of sandstone, and the shearing and pressure of the overthrust has caused little damage to the coal. The one above has suffered much more, owing no doubt to weaker covering beds, and there is evidence that there has also been sliding and bending of the overlying rocks. The sliding plane seems to have been mostly along the plane of seam No. 3.

In the beds immediately under the mass of the mountain little crumpling could take place, and the beds must have



SECTION AT BANKHEAD MINE, EAST SLOPE OF CASCADE MOUNTAIN.

slidden bodily or in sections at different planes. In the beds at a distance from the overlying mass some relief could be had by the beds crumping up in front of the load. The rolls thus made would at the sliding plane be filled with broken material, and there would be a local thickening of the series along the face of the overthrust mass. The folds at Canmore are probably of this origin, but there are some in the beds at Bankhead that can be directly traced to this cause. In the prospect work at the top of the hill half a mile north of the mine, No. 3 seam apparently showed 100 feet of coal. This afterward was found to be but a mass of broken coal occupying a triangular area in vertical section. The foot wall was not disturbed but the roof had been forced back to nearly a vertical position, and below, the seam was continued with a thickness of only about five feet. In a cross cut to this same seam at the temporary entry on No. 2 seam the rocks were apparently undisturbed till No. 3 was approached, then the dip increased and the seam was found standing vertical, and farther on the dip reversed and where work was stopped the rocks were nearly horizontal. This points to a possibility of the tunnel passing beneath another of these rolls or pockets of broken coal. The foot wall of the mass was smoothed and showed small horizontal ridges, as though from the lateral pressure. Another example of buckling in the beds was observed on the walls of a gully five miles north of this place, but it can not be correlated with the same seam as at the mine. It probably is in somewhat higher beds, and if so there is some reason to think that No. 3 may as it is traced in the mine, prove to be workable in its northern part.

The effect of this buckling on the coal seams above the plane of sliding will be to form a series of waves such as are in the Canmore mine. Other sliding planes may, however, be found, but they are as likely to be in the thin bedded shales as the coal seams and will there cause no great amount of damage.

The work so far at Bankhead has disclosed two very regular and little disturbed coal seams, perhaps the best feature of

the coal-field. The smashing of No. 3 seam is probably at its maximum at the south end and may diminish northward. The rolls do not seem to be horizontal, as the disturbance which is noted near the entry on No. 2 dies away farther in, but it must be admitted that the tortuous course pursued by this gangway at the entry is attributed to the proximity of a cross fault which divides the range to the east along the valley of Minnewanka Lake, and helped to make the great break between Mounts Rundle and Cascade. The section across the measures at the mine is emphasized to show the probability of portions of No. 2 being thinner opposite the extra pressure points of No. 3 or thickened by the relief of pressure opposite the pockets. One of the points where extra pressure might be expected would be between the two entries or below the temporary works. The state of this seam is no doubt already known, as there is being a slope put down on it at the mine to meet the main entry.

The thickening or apparent increase in the thickness of the measures caused by the crumpling of the strata is probably confined to the unloaded portion, and near the fault line the measures may be expected to increase their dip. A coal seam was found just under the foot of the mountain, and as it was of soft coking coal it was determined to test the seam by going down on it by a slope. Instead of a steep dip the seam started at the normal but bent downward and was carried still farther by a series of small faults which appear to run along in front of the mass of the mountain. By this series of steps the dip was increased to about 80 deg. This seam appears to be too close to the fault plane and is probably too much crushed to be profitably worked, but there seems to be no reason to suppose that higher up it may not have some portions that will be all right.

The two lower seams are of semi-anthracite, very nearly as hard as those in the old mine at Anthracite, but from the samples taken from the outcroppings of the higher seams along the hillside softer coal will probably be found, and after the cross entries are finished the shipments may include an-

thracite, steam coal and coking coal. The seams at Anthracite are slightly harder, but it must be remembered that the mining there is all from below what in this section is the main entry. I need not point out the great advantage there is here in having such a great body of coal above the entry.

It may be asked, how is it that as these beds are in regular ascending order above Carboniferous limestones, the age assigned to them is so much later than the Carboniferous? Is there not a chance that they are really the upper part of the Carboniferous, or near the age of the coal measures of Nova Scotia? The answer is that in the shales below the coal of this area Belemnites and Ammonites, with a few other shells known to be Cretaceous or Jurassic, have been found. The plants also that are associated with the coal bear but distant relation to the fern trees of the Carboniferous. At Anthracite and Canmore there have been recognized five species of ferns that have survived with slight change to the present day. Of the allied species, Cyads and Conifers, which can hardly be traced back as far as Carboniferous times, eight are found and all are related to modern types.

DISCUSSION.

The President.—We are all indebted to Mr. Dowling for his interesting paper on this coal field, which is going to be of more importance now than it has been in the last twenty years. Twenty-two years ago, in the summer of 1883, the first coal was found there along Devil's Head Creek. I was one of the first to go out there in the fall of 1883 to examine this new discovery, and I advised the men to work during the next winter nearer the railway at a point afterwards called Anthracite, so I can claim to be the founder of "Anthracite." That was in 1883 and it shows how long it takes to bring out only one small district even one right on a railroad. Much more interest is being taken to-day in that coal basin of the Bow River Valley, near Cascade Mt. I would like to ask Mr. Dowling if

these coal measures extend further north inside of the mountains?

Mr. Dowling.—That would be the explorations made by Mr. McEvoy.

The President.—Would it be the case there also of cretaceous coal basins inside of the mountains?

Mr. Dowling.—No, not inside the first range.

The President.—Further north than where Mr. McEvoy explored?

Mr. Dowling.—No. I believe, however, that explorations are to be continued in that direction in the near future.

Mr. Jas. White.—I may say that, in 1885—when on the staff of the Geological Survey—I made surveys in the Rockies between the Canadian Pacific and the North Saskatchewan. We found that the Cretaceous troughs did not cross the North Saskatchewan, inside the mountains, and the explorations of Drs. Selwyn and Dawson show that the Cretaceous is not present in Pine River Pass nor in the vicinity of Peace River—the valley by which the Grand Trunk Pacific proposes to cross the Rockies. At the latter point the mountains are narrowed down to a width of only 35 miles as compared with a width of 55 miles, where crossed by the Canadian Pacific, and are entirely composed of limestone. Of course, it is not at all certain that the Grand Trunk Pacific will go through by the Peace River. They might cross by Pine River Pass or by the Yellowhead to "Tete Jauie Cache" and then, from there strike over to Port Simpson.

NOTES ON THE LIFE HISTORY OF COAL SEAMS.

By J. C. Gwillim.

Current mining literature is saturated with the subject of the genesis of ore bodies. The matter of their origin appears to have an economic interest, hence it is that these enquiries meet with so large an interest. To the metal miner there are many associations which incline him to faith or fear in the matter of values and permanence, and these are largely connected with the origin of the ore body.

Coal, on the other hand, finds commercial or economic interest at a later stage in its history. Its origin, except in the broadest sense, does not seem to throw much light upon its production.

The coal miner begins operations on the assumption that a coal seam varies very little in quality and thickness over a wide area. To him the matter of associated rock is purely physical. It affords a good or bad roof and floor, and is without influence upon the coal seam in the matter of origin. Dykes, Granite, Porphyry and a circulatory system seldom enter into his field of operations. The coal seam is looked upon as a stratum, and if of workable size and quality is approached with faith in these attributes and a neglect of its genesis.

It is commonly believed that coal is derived from plant life which must have accumulated to great thickness on aqueous sediments, and in turn was overlain by other aqueous sediments.

It is a matter of speculation as to the conditions which produced these coal-bearing strata. The natural forces which caused alternate accumulations of vegetable matter over vast areas, then evenly submerged and silted them up for another accumulation and another submergence, repeated many times, could not have been of the catastrophic order,

but rather of so nice an adjustment that we are compelled to wonder, more especially, as terrestrial evidences are so rare and sporadic in the sedimentary formations as a rule.

In the matter of plant life we have several suggestions. The growth of bogs, comparatively rapid and of commensurate thickness, but apt to be of smaller area than known coal seams.

The collection of drift and waterborne plant life amongst conditions which provide for a floor and a roof of aqueous sediments, but hardly for the regularity and extent we find in coal seams.

The growth of forests in place along wide swamps or sea margins, accompanied by a continued depression and silting up of these flats, conditions which seem to account for extent, even thickness, and a succession of burials beneath sediments of like extent and uniformity. The forest growth, however, must have had a curious compost to root itself in. Concerning peat as a source of coal: as we know it, peat grows in clear fresh water in temperate and sub-arctic climates. These peat bogs are insular, and sporadic, and unless, in the coal-making periods, they bordered on sea shores, can hardly offer sufficient magnitude, or the conditions of silting up with aqueous sediments.

The presence of slate and silicious aluminous ash in most coals is also against them, because their own ash is mostly limy and not of outside origin, since they require clear standing water.

Whatever the possibilities of peat in the way of growth sufficient to furnish a 40-foot seam of coal from material 80 per cent. water may be, we still need the wide and regular earth movements which put a roof of such persistent composition over it, and such appears most possible on a sea margin or a Tundra, slowly sinking, and alternately above and below sea level as the sediment gained in thickness. This would appear to involve brakish water which might be fatal to bog plants.

On venturing these suggestions on origin it is becoming to confess the general ignorance. They are made from the physical point of view; a study of the composition of the plant life and fossils should settle the peat or forest, bog or marine origin. That coal seams are still attributed to peat bogs, Carboniferous and Cretaceous forests, and to spores and drift is sufficient apology. Commending the origin of coal to the enquiry of pure science, both in the field and in the laboratory, we may with more certainty study some of the changes which have taken place since the plant life has been sealed up in the sediments and converted to lignite.

The following Canadian examples illustrate analyses from a watery lignite upwards to a graphite anthracite:—

LIGNITE.	Moisture	L.C.	Vol. C	Ash	Age
Moose River, Ont.....	12.0	46.0	39.0	3.0	.....
Souris, E. Assa.....	21.84	38.64	35.12	4.4	Laramie
Medicine Hat, W. Ass...	19.90	41.58	33.33	5.19	Cret.
Lethbridge, S. Alta.....	5.5	49.7	30.2	4.7	Cret.
BITUMINOUS.					
Nicola, Southern B.C....	2.02	56.78	36.7	4.49	Mi.
Vancouver Island, B.C..	.....	56.41	31.0	12.59	Cret.
Blairmore, S. Alta.....	4.00	55.6	26.7	14.7	Cret.
Cape Breton.....	1.10	57.32	35.61	5.91	Carb.
Coal Creek, Crow's Nest, B. C.....	0.41	68.36	24.78	6.45	Cret.
SEMI-BITUMINOUS.					
Morrissey, Crow's Nest, B.C.....	0.65	78.88	13.48	6.40	Cret.
Canmore, W. Alberta....	1.0	81.5	13.6	3.9	Cret.
SEMI-ANTHRACITE.					
Sheep Creek, W. Alta...	0.6	74.1	11.8	13.5	Cret.
Cascade Creek, W. Alta.	1.4	81.0	11.0	6.6	Cret.
ANTHRACITE.					
Cowgitz Mine, Queen Charlotte Island	1.6	84.0	5.0	8.0	Cret.
Camp Anthracite..... .	2.14	93.72	0.78	3.26	Cret.

There is not any doubt as to the fact that the same coal measures, possibly the same seams, may pass from a bituminous to a semi-anthracite, under pressure and the heat involved; also without much pressure; and, by heat alone from intrusive molten rocks.

Between the lignites and the bituminous there is no great apparent difference in appearance, or in the amount of the constituents; between the coking bituminous, and the non-coking there is less difference still. Then there is a gradual lowering of volatile matter from about 30 per cent. through the semi-bituminous to the semi-anthracite of 8 to 12 per per cent. volatile matter. Here, again, there is a subtle difference, not proportionate to the slight difference of analysis between the semi-anthracite and the semi-bituminous.

The semi-bituminous of 13 per cent. volatile matter at Canmore is a strong steam coal. The semi-anthracite of Bankhead, from 8 to 13 per cent. volatile, is not a steam coal under the regular conditions of fire boxes, the measures are the same.

The change from lignites to bituminous coal does not appear to call for much loss in volatile matter considering the free gas present in the latter, nor for great difference in age. There is a loss of moisture and a tendency to coke. An ultimate analysis will show more free hydrogen, perhaps twice as much, and this free hydrogen may account for the coking properties.

As one approaches the Rocky Mountains from the plains, ther is a notable decrease of water in the coal. This is not, however, an observation on coal of the same horizons, although any one seam, such as the Lethbridge seam, may show less moisture where it is found nearest the folding influence of the mountains. This seam, however, is of later formation than the Blairmore, Crow's Nest and Banff coals. Still younger coals within the folding of the foot hills, show a character nearer bituminous than Lethbridge.

The fields within the Rocky Mountains proper, and immediately to the East of them, appear to be of one age and series in the Lower Cretaceous.

The variations, therefore, in these fields are not due to difference of age. It is believed that they are not greatly due to the original organic matter, or to heat, but principally to pressure and its attendant heat.

Whenever the cretacous basins are constricted between the limestone mountains, and show the greatest pressure, these coals appear to lose volatile matter and to grade up from semi-bituminous to semi-anthracite. This condition, however, seems to be assisted by the enclosing strata. Strong beds of sandstone, for instance, do not fold so readily as the shales and slates, but transmit pressure more perfectly to the coal. Semi-anthracite is found between sandstones and highly volatile bituminous coal in the shales above it.

These less volatile coals usually pitch at high angles, and have received the lateral and inclined pressures of the mountains nearly normal to their seams.

In the change from Bituminous coals of, say, 25 or 30 per cent. volatile matter to 8 or 12 per cent. volatile matter, there must have been a great volume of gas disposed of. It may be possible some of this becomes a solid. In any case what becomes of the volatile matter of a coal formation carrying in the aggregate 100 feet of coal ?

A reduction of volatile matter from 25 to 10 per cent. would mean, in such a case, 15 million tons of gas per square mile, which, figured into volume, would be as astonishing a loss as natural gas is as a find.

Much of this less volatile coal is crushed and sheared by movement along the seams. This would help to liberate the gas. At times a coal seam has offered so favorable a plane of relief to the pressures that it has formed part of a fault line, and the coal, a loose polished and friable mass, has been forced to fill irregular spaces, and even follow fault lines across the measures.

This tendency to squeeze has affected workable seams, causing them to pinch from many feet down to a few inches with a proportionate slacking or crushing of the coal.

Alteration to semi-anthracite, and anthracite by heat without much attendant pressure, are also in evidence in other regions.

At Union, on Vancouver Island, it is stated that anthracite occurs within a limited distance of the intrusion of dykes through the coal seams.

Anthracite, or semi-anthracite, showing little sign of pressure, has also been found on the main land east of Port Simpson, where it has probably been affected by volcanic flows or intrusions.

A notable case of this kind is given by E. T. Dumble, in Vol. 29, of the American Institute of Mining Engineers.

At Santa Clara Coal field, Sonora, Mexico, he says:

> Laccolites of igneous rock have penetrated a coal-bearing series of Trissic age. The coal seams are altered in places to coke, Anthracite, and even Graphite. One seam has three feet of coke underlain by two feet of anthracite; in other places sporadic areas of coke and anthracite occur.

The conditions which accompany the semi-bituminous and semi-anthracite coals of Western Canada, seem to show them to be the result of alteration, chiefly by pressure. Time and original organic differences do not seem responsible mainly for the differences in quality.

Although the persistency and extent of these coal series is very great, the thickness of any one seam, or, in many cases, the seam itself, is not continuous. The plant growth was more less continuous over vast areas but had local increase. These original differences have been added to by the pressure they have since undergone.

DISCUSSION.

The President—You will all agree with me that this is a very interesting subject scientifically. The knowledge of the changes in coal seams is also of great practical importance when it comes to working these coal seams, and to sizing up the value of these new coal fields in the mountains.

Mr. Dowling—I would like to ask Prof. Gwillim, referring back to my paper again, for some information on the structure at Bankhead. No. 2 seam below the entry, I suggested, would probably be affected by the fold on No. 3 (referring to section at Bankhead). I think Prof. Gwillim probably has the results of later development work on Nos. 2 and 3 seams and can tell us whether any crushing or widening of these seams was found.

Prof. Gwillim—Just where they start in on these two lower seams appears to me to be in a zone of fairly strong pressure. There is a great deal more disturbance there than is the case further north along the mountain. Then they drove to the left hand side, thinking to strike the other seam, and they did strike another seam, but only got about two or three feet of coal. That work was done while I was there. It was done in the winter of last year, and I only saw it last summer. They sunk on No. 2, and when they got down perhaps about 100 feet, they got into a fold with crush coal in the seam. That may be the explanation of the trouble on No. 3. What Mr. Dowling illustrates there as the upper measures, are mostly shales, and about 2,000 feet thick. The coal here is sometimes crushed, on account of the great folding transmitted to the coal by the shales. These two lower seams, on the contrary, had been protected by beds of sandstone. Then they went further into the mine several hundred feet, and found No. 3 no better. The seam was about three feet thick. I would like to ask Mr. Dowling, in reference to the C.P.R. looking for coal in the vicinity of Regina, is there any possibility of lignite there?

Mr. Coste—There was a boring that went through the drift at Belle Plaine, twenty miles west of Regina. Dr. Dawson gave the log of it in a paper on "Certain Borings in Manitoba and the Northwest," read before the Royal Society of Canada. This log shows that they went through the Laramie and the Niobrara, and finished in or near the top of the Benton shales at 1,640 feet; no coal was found, all sandstone and shales, mostly shales.

Mr. Dowling—There is a great thickness of boulder clay over the country east and south of Regina. I would say that boring operations there would be very troublesome. I cannot find many records, and none from near the banks of the Assiniboine, which went really through the drift. Pieces of coal have been brought up from wells at Regina, which seem to indicate the possibility of lignite seams passing to the east of this place. In Southern Manitoba, and in some of the western parts, notably near the town of Souris, there are many fragments of coal in the boulder clay. I do not know where they come from, except in a general way. The direction of the glacial motion was from the northeast, so that the coal probably came from that direction.

Mr. Coste—Are they coal or bitumen?

Mr. Dowling—Small coal seams have been found in the Dakota sandstone, which outcrops in a few places along the foot of the Pembina Riding and Duck Mountains, which form the second prairie steepe. The coal in the drift may thus have been derived from the Dakota sandstone.

Mr. Coste—This coal question in the West is a very interesting one. It is one destined to become of the greatest importance to our country. We have hopes of many more new good coal fields being found, in the mountains I mean. As far north as Alaska along the Pacific coast there are good coal fields in the Cretaceous. Last summer I examined these in Alaska near Controller's Bay, eighty miles west of Mount St. Elias, a very large new coal field in which had already been found fifty seams, more than thirty of which are three feet thick and one is thirty feet thick. The very wide distribution of the Cretaceous coal fields from the United States to Alaska to my mind indicates that there is a chance of getting many more of these coal fields on both sides of the mountains in British Columbia. I think we have not heard the last by any means of these good Cretaceous coal fields in the western part of our country.

Mr. Garde—I came here as one of the members from British Columbia, and it is somewhat surprising to observe, con-

sidering the possibilities of that Province, how the country has been so neglected. In British Columbia we have not only coal suitable for fuel, but also for coking purposes, as for example, the Crow's Nest coal. We have water power and minerals of all kinds. When one considers that copper can be mined and smelted in the Boundary District, it is an achievement of which we may well be proud. We have an unequalled climate. I have then to ask—why is it that the country has not shown greater progress? I am a firm believer in the possibilities of that country, and I also believe that we have a bright future before us. The reason, however, that the Province has not advanced as rapidly as we should have liked to have seen it, is simply due to the fact that mines have been bought at absurdly high figures, not in any way justified, and companies have been grossly overcapitalized. It is difficult to convince eastern people of the potentialities of that country, and I am therefore pleased to see that at this meeting so much attention has been given to the resources of British Columbia.

Mr. Dowling—If Mr. Garde had been a coal man he would have called attention to the great wealth of coal in the Crow's Nest Pass and said that this field could equal the present output of the world for twenty-five years.

Mr. Garde—I am not going into the details of any particular mine, at the same time the great possibilities of the western coal fields of Canada and particularly of the one of the Crow's Nest Pass which is the only one that will produce to-day a coke that will stand the furnace are very great. It is not because I do not realize the future that Mr. Dowling speaks of, but because it would be too much for me to go into at the present moment.

THE ECONOMICAL TREATMENT OF SULPHIDE ORES.

By C. B. Jackes, M.A., LL.B.

In the latter part of 1896 I had my attention first directed to the great quantities of sulphide ores in the Province of Ontario, promising great wealth to enterprising capitalists could some inexpensive method of treatment be applied to them. Later I learned that there were almost incalculable quantities or such ores through the Dominion. In British Columbia there are many millions of tons of sulphides of silver, lead and zinc, high grade ores, until lately, and indeed to a large extent up to the present, left lying on the dump because of the absence of local means of treatment. The cost of transportation to and treatment by present methods at the nearest smelter was found in practice to be prohibitive. In Nova Scotia also are similar large quantities of antimony sulphides carrying high percentages of gold, offering very tempting and very aggravating opportunities for experiment to the mining men of that part of Canada.

In my own case, I was interested in the tremendous deposits of the Jackfish region, where exist veins from twenty to forty feet wide, having for the most part a quartz gangue, mineralized with sulphides carrying gold, silver, copper, and lead. The gold being associated with the sulphide of copper either in the form of copper pyrites or chalcopyrites, and the silver being associated with the sulphide of lead or galena. For the most part the portions of the veins carrying the argentiferous galena were almost four feet wide and quite distinct from the part carrying the copper and iron sulphides, and offered but little difficulty to a more or less complete separation. Nevertheless, it was at that time considered that the cost of mining, freightage across the international boundary, the smelting and refining, and incidental loss of by-

products, set up a prohibitive barrier to the commercial handling of such ore.

For the past six or seven years I have been searching with considerable persistency and very large expenditure of money for a satisfactory method of treating, on the spot, the ore mentioned, and as an incident of that search I learned the fact that many others were also on the trail, and that there were other ores than argentiferous galena in urgent need of some method of reduction that would leave a margin of profit.

At first thought one is inclined to ask:—"Why did not the different local governments erect smelter plants in various localities to treat such ores?" One has only, however, to think for a moment to understand how impossible it would be for the government, however desirous to lend a helping hand, to set up a lead smelter here, a copper smelter there, an antimony smelter somewhere else. The variety of metals is so extensive, the distance between the mines so great, and the cost of such smelters so enormous, that it would soon exhaust even the much disputed surplus of the Ontario Government in a futile attempt to supply the demand.

In the course of my researches I found that annually in the United States, alone, some ten to twenty patents were issued for some method of treatment bearing upon sulphide ores as a class, for some apparatus relating thereto, or for special treatment of some particular ore. I found that almost without exception such patents related to either pyritic or electrical treatment of the ore or ores, and that the "wet method" had apparently been abandoned to the laboratory as too expensive for actual practice on a large scale.

About eighteen months ago I received some information respecting a process that seemed to offer great possibilities for cheap treatment of such ores, more particularly in the manufacture therefrom of paints and pigments inasmuch as it promised to eliminate much of the work now required by the methods in practice, by, to some extent, reversing the steps ordinarily pursued. For instance, in the manufacture of white lead the ore undergoes an expensive treatment to con-

vert it into pig-lead which is then subjected to a process covering several weeks to convert it into the carbonate or "white-lead" of commerce. By the new process, the conversion into pig-lead is avoided, and the white-lead produced directly from the raw ore in a state of purity and smoothness of grain not attainable by any other process. The saving of by-products, including sulphur, the recovery for use over again of the re-agents, and many other advantages, seemed to me to make the new process well worthy of investigation, and I thereupon proceeded to investigate it.

It is many years since I studied chemistry. Many new discoveries in the treatment of ores, of which I had not kept track, had been made in that time, and even the nomenclature had been materially changed, so that I found personal investigation at first impossible. With expert assistance, followed up subsequently by practical tests, I have satisfied myself that a discovery of real value to science and of vast possibilities had been made, and it is my desire in presenting this paper to direct the attention of the Institute as a whole to this new process, and to request the co-operation of that part of the membership interested in chemical research in thoroughly testing it with the view of making it such a commercial success as it is now undoubtedly a laboratory success. As soon as that fact can be demonstrated by trial on a much larger scale than has yet been attempted, there will be at once brought to market a very large tonnage of lead, zinc and antimony ores at present either entirely undeveloped or lying in the dumps, where they have been left awaiting some cheap process of treatment.

As a large part of the success of the process depends upon the apparatus used, I have found it advisable to annex as an appendix to this paper a condensation of the specifications leading to the patent granted for Canada to George Edward Kingsley, the patentee of the improved apparatus recommended for use in the process.

Although in practice almost any sulphide ore may be treated by the aid of this apparatus and process, yet some are

more susceptible to treatment than others, and in some cases a preliminary treatment by roasting or otherwise may be advisable. The ordinary sulphide of lead, either with or without silver, arsenic or antimony, seems to lend itself so freely to the treatment, and the products of decomposition are so valuable commercially and certain of ready market, that I have therefore selected that ore for the purpose of illustration; and in setting forth the re-actions taking place from point to point in the reduction of the ore, I have not hesitated to avail myself freely of reports from scientists who have looked into the matter, and of the text-books on the subject in hand.

The galena is first freed, as far as possible from gangue, silicious, calcareous and earthy matters. It is then ground to 40 mesh or thereabout, and placed in the upper series of tanks and the dilute nitric acid, containing in practice a small amount of nitrous acid, admitted, and the temperature raised to and maintained at about 80 degrees C in the manner described in the appendix. Decomposition immediately commences.

$$Pb\,S + 2\,H\,N\,O_3 = Pb\,(N\,O_3)_2 + H_2\,S$$

The hydrogen sulphide thus liberated reacts on some of the nitric acid according to the usual re-action.

$$2\,H\,N\,O_3 + 3\,H_2\,S = N_2\,O_2 + 4\,H_2\,O + 3\,S$$

being summarized thus:

$$3\,Pb\,S + 8\,H\,N\,O_3 = 3\,Pb\,(N\,O_3)_2 + H_2\,O_2 + 4\,H_2\,O + 3\,S$$

The nitrous acid present in the nitric acid is also reduced more or less completely by the hydrogen sulphide.

$$2\,H\,N\,O_2 + H_2\,S = N_2\,O_2 + H_2\,O + S$$

It is desirable to keep the nitric acid of a uniform strength so that when the hydrogen sulphide is decomposed with the liberation of sulphur, there will be no oxidation by the nitric acid to sulphuric acid. The formation of sulphuric acid would result in the precipitation of lead sulphite, thus ren-

dering the resulting white-lead or other lead pigments impure.

The gases from the reaction between the nitric acid and the galena pass from one receptacle to another, so that they are continually in contact with the ore and the dilute acid. In this way there is more or less decomposition of the nitrogen tetroxide by the water of the dilute nitric acid and nitrous acid, which causes the galena to be exposed to the action of the acids in the nascent state, thus increasing the facility of the re-action between them.

The nitrogen dioxide, which is formed by the action of the nitric acid on the galena, is mixed with air, whereby it is converted into nitrogen tetroxide.

$$N_2 O_2 + O_2 = N_2 O_4$$

The nitrogen tetroxide is passed into absorbing tanks filled with water, whereby it is converted into nitric and nitrous acids and is absorbed.

$$N_2 O_4 + H_2 O = H N O_3 + H N O_2$$

during this absorption and in the presence of the excess of oxygen and, probably by the action of some catalytic influence, a part of the nitrous acid is converted into nitric acid.

$$H N O_2 + O = H N O_3$$

in dilute solutions nitrous acid rapidly decomposes into nitric acid and $N_2 O_2$.

$$3 H N O_2 = H N O_3 + N_2 O_2 + H_2 O$$

By aerating the solution a large portion of the nitrous acid can be converted into nitric acid.

The small amount of nitrous acid in the nitric acid before mentioned appeared to materially aid the activity of the nitric acid in decomposing the galena.

The silicious and mineral matters accompanying the galena, which are insoluble in dilute nitric acid, are left in the decomposing tanks on racking off the solution of nitrate of lead and other metals.

With this residue is also left the sulphur precipitated by the action of the hydrogen sulphide on nitric acid. This sulphur is converted into sulphuric acid in the usual way, and used as a part of the process.

When the solution of nitrate of lead is drawn out from the sulphur and silicious residue it will be found to contain as a rule some ferric nitrate. This is eliminated by the addition of dry white-lead (basic lead carbonate) which precipitates the iron and ferric hydroxide containing some basic ferric carbonate.

$$2\ Fe\ (N_2O_3)_3 + 3\ Pb\ C\ O_3 + 3\ H_2\ O = 2\ Fe\ (H\ O)_3 + 3\ Pb\ (N\ O_3)_2 + 3\ C\ O_2$$

This ferric hydroxide is dried. If desired it can be calcined to obtain particular shades of color. It forms a pulverulent iron oxide pigment which is sold as such. On account of its fineness, control of color and carrying power, it will find a ready sale.

A greater part of the iron can also be precipitated with potassium ferrocynide, yielding a good quality of blue.

The solution of lead nitrate is next precipitated with a mixture of sodium carbonate and hydroxide:

$$3\ Pb\ (N\ O_3)_2 + (2\ Na_2\ C\ O_3\ 2\ Na\ O\ H) = 2\ Pb\ (O\ H)_2 + 6\ Na\ N\ O_3$$

as nitric acid is a stronger acid than nitrous acid, the nitric acid will remain free in the solution of the lead nitrate and will be converted into sodium nitrate by the alkali.

$$H\ N\ O_2 + Na\ O\ H = Na\ N\ O_2 + H_2\ O$$

By varying the proportions of the carbonate and caustic, white-lead of different properties and basicity can be obtained. Fineness of particle, toughness, gravity, covering power, etc., can be influenced by the method of precipitating, temperature of solution, pouring the alkali compound into the lead solution, or the lead solution into the alkali compound, etc., thus affording a wide latitude in the properties of the product.

The solution of lead nitrate may also be precipitated with other substances and various products obtained, as, for instance, the nitrate, sulphate, chloride, oxychloride, chromate, litharge, acetate, etc.

Any salt of lead may be obtained from the solution of lead nitrate by methods of treatment known to any chemist.

In the production of several of the pigments from the solution of lead nitrate it is not necessary to remove the accompanying iron salts, since the iron is either not precipitated, as in the case of sulphate, chloride, etc., or its precipitation may be desirable, as in the case of some of the chromates.

The sodium nitrate, containing some nitrate obtained from the precipitation of the lead nitrate by the alkali carbonate and caustic and from the washing of the precipitated white-lead, are evaporated in a suitable apparatus and treated with sulphuric acid (made from the sulphur obtained from the decomposition of the galena with nitric acid).

The nitric acid gas thus obtained is led through tubes that pass through the decomposing tanks, and thus affords the heat to raise the contents to the temperature found best suited to the re-action; the sodium nitrate is also decomposed, forming N_2O_4 and N_2O_2, the latter being converted by the oxygen of the air into N_2O_4.

The vapors of nitric acid and N_2O_4 are then passed through water absorbers whereby the solution of nitric containing some nitrous is obtained. This acid is mixed with the acid obtained by the absorption of the gases from the decomposing tanks, brought up to the strength required and used to decompose fresh galena.

The nitre cake obtained from the re-claiming of the nitric acid is sold as such.

From the foregoing it will be seen that the raw materials in this process are (1) galena, (2) sodium carbonate, (3) sodium hydroxide. These are all common articles of commerce.

The chief products are (1) white-lead, (2) lead pigments, including the litharge.

The by-products are (1) iron pigments, (2) nitre cake, (3) nitrogen oxides (reclaimed), (4) sulphur, (reclaimed).

These by-products are articles of commerce and can always be sold at the market price.

In a properly constructed and run plant there should be no appreciable loss of nitric acid, but should there be it can easily be supplied.

The precipitation of the ferric salts can be effected with calcium carbonate, litharge, zinc oxide, and carbonate, barium carbonate, etc. The choice of ferric precipitant will depend on the conditions governing the properties of the lead product.

Should the galena contain silver, it can be removed from the lead nitrate solution by the cautious addition of salt or hydrochloric acid up to the point of the precipitation of the silver, but not in sufficient quantity to precipitate the lead as chloride; or by passing the lead nitrate solution through lead fibre.

If the galena contains copper, it can also be removed by passing the lead nitrate solution through lead fibre.

If the lead contains arsenic and antimony, these metals will be precipitated in conjunction with the iron during the purification by precipitation with lead carbonate, etc., since they form salt with iron insoluble in water, and hence are precipitated on neutralization of the solution. The removal of arsenic from solutions containing it with ferric hydroxide is a well known method.

If the solution of lead nitrate contains calcium nitrate it cannot be removed economically. In this case it can probably be separated sufficiently for all practical purposes by a process of fractional precipitation, the first precipitations consisting of pure white-lead, the last precipitation would contain the calcium carbonate with the white-lead, and this can be used for pigments of a lower grade. By the use of the proper concentrating apparatus, however, galena should

not contain an appreciable amount of calcarious, silicious or other kind of gangue.

If it is desired to make litharge from the solution of lead nitrate, the solution is precipitated with caustic alkali, when a lead oxide, free from grit crystals and of remarkable softness and fineness of comminution is obtained, which should command a fancy price, especially as it is also free from iron.

If the galena contains zinc, and a separation of the metals cannot be effected on concentrating tables, the nitrate solution will contain nitrates of both lead and zinc.

If desired the zinc may be separated by neutralizing with ammonia and precipitating with sulphide of ammonium. But, in general, it will be found best to make a pigment consisting of a mixture of lead and zinc carbonates, hydroxides and oxides. Such a pigment will compete successfully with the mixtures of lead and zinc whites made by mixing lead and zinc pigments, as much of the cost of manufacturing would be saved. Experience also shows that a mixture of lead and zinc whites produced directly from a mixed ore gives better results than a pigment made by mixing the two.

If it is desired to make metallic lead from the lead nitrate solution, a metal of great purity can be obtained by electrolytic deposition without interfering with the general work of the press. Such a press would avoid the entire cumbersome and wasteful smelting process now in use, which, at best, produces an impure metal.

The possibilities of the process with respect to lead ores are by no means exhausted in the above description, which is intended to illustrate the peculiar cyclic action of the apparatus, applicable to other acids as well as the nitric, whereby the acids, which form the most expensive portion of the re-agents used, are recovered and used again with very small loss.

APPENDIX.

This invention relates to improvements in apparatus for the economical extraction of metals from sulphides and other

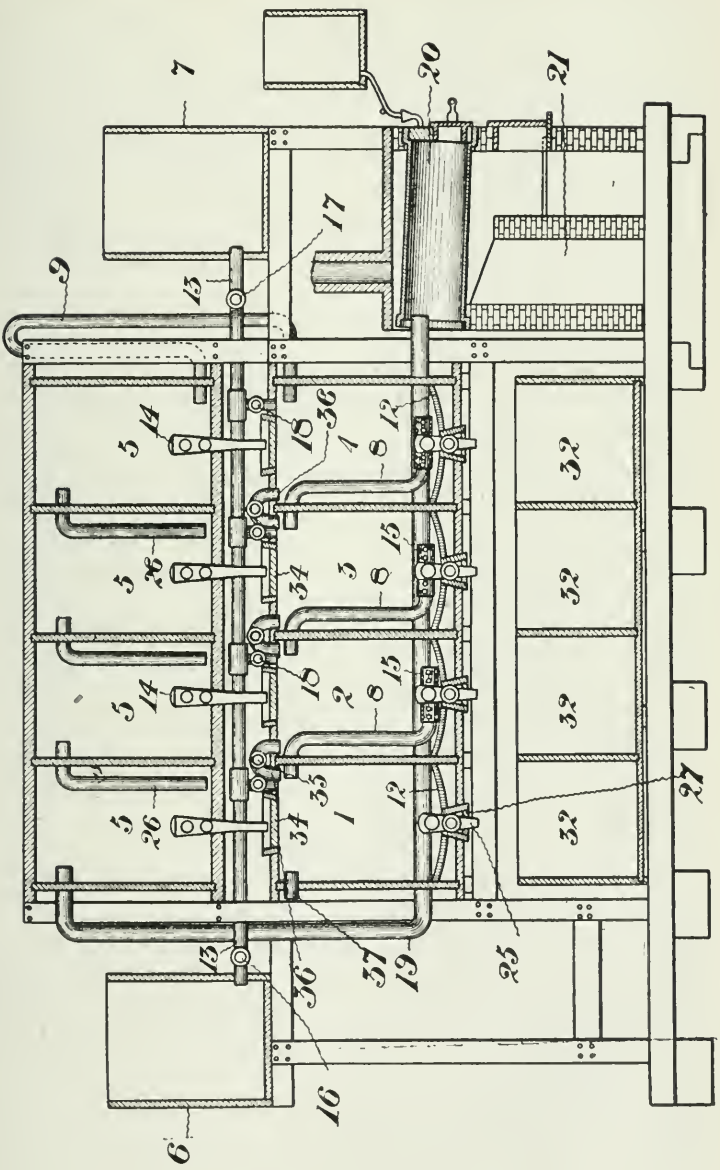


Fig. 1.

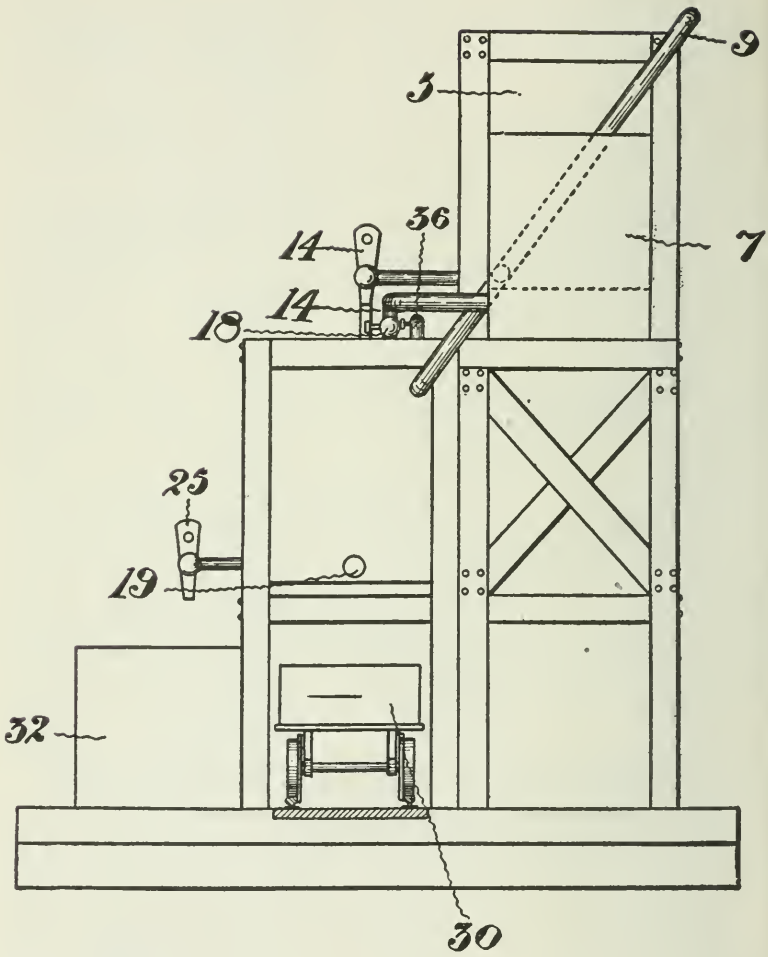


Fig. 2

ores in a form ready for market, and the production during the process, of valuable by-products.

It is further aimed to construct the apparatus so that in use its results are cyclic in its nature, and, therefore, conducted with comparatively small loss of the original re-agents employed.

With this object in view, the invention consists essentially of the parts hereinafter more specifically described and then definitely claimed.

Fig. 1 is a front elevation of the plant, partly in section.

Fig. 2 is an end elevation of the plant, partly in section.

In the drawings, like letters of reference, indicate corresponding parts in the different figures.

Referring particularly to Fig. 1.—1, 2, 3 and 4 are square chambers provided with false bottoms 12, and, preferably lined with thin fire brick, porcelain, enamel, or other acid resisting material.

These chambers have openings in their tops, provided with doors 34, by means of which they may be tightly sealed.

Above and behind these chambers are arranged a series of similar chambers 5, adapted to receive dilute acid.

The bottom of each of these chambers is connected with the top of the adjacent chamber by means of a pipe 26.

The bottom of each of the chambers 1, 2, 3 and 4 is connected with the top of the next chamber in the series by means of a bent pipe 8, the lower end of each pipe being provided with a perforated distributor 15.

The tops of these chambers are connected by the bent pipes 36, each having a stop cock 35 therein. In the chamber 1, an opening is formed in the side, near the top, closed by a suitable plug 37.

Each of the ore receptacles 1, 2, 3 and 4 is also provided with a spigot 25, arranged to discharge into the series of vats 32.

Each dilute acid receptacle is provided with a spigot 14, arranged to discharge through the opening in the top of the corresponding ore receptacle in front of it.

Beneath the chambers 1, 2, 3 and 4, are rails laid, and a car 30 provided to run thereon.

Dumping doors 27 are provided in the bottom of these chambers, through which their contents may be dumped into car 30.

6 is an acid reservoir, and 7 a water reservoir, connected by the pipe 13, provided with stop cocks 16 and 17.

This pipe 13, is connected by suitable branches with the chambers 1, 2, 3 and 4, and these branches are provided with the stop cocks 18.

The top of the chamber 4 is connected with the bottom of the acid chamber 5, above and behind it, by means of the inverted U-shaped tube 9.

Adjacent to the chamber 4 is a retort 20, provided with a furnace 21.

The pipe 19, leading from the retort, passes through the chambers 1, 2, 3 and 4, near their bottoms. The pipe then leads upward and passes into the end chamber 5, above and behind the chamber 1.

The retort is shown provided with suitable means for feeding acid thereto, but such forms no part of my invention.

The operation of the apparatus is substantially as follows:

The ore is first ground, or crushed, to pass through a 30 or 40 mesh sieve, and then placed in the ore chambers 1, 2, 3, and 4, through the air-tight fitting doors 34.

The acid is mixed to the proper strength in the receptacles 5.

Acid and water are then admitted from the chambers 6 and 7, through the pipe 13, into the ore chambers 1, 2, 3 and 4.

A suitable salt and acid are heated together in the retort, and the heat and vapors therefrom pass through the pipe 19 and raise the temperature of the contents of the ore chambers sufficiently to greatly stimulate the chemical action therein.

The gases and vapors resulting from the action of the acid on the ore rise in the chambers 1, 2, 3 and 4, and are forced from each chamber in succession, through the pipes 36, into the bottom of the next chamber, thus keeping the ore con-

stantly in agitation, and obviating the necessity for any artificial stirrer, and finally, any excess from the chamber 4 is forced through the pipe 8 into the bottom of the chambers through the pipes 26.

Here any metallic values contained in such gases are condensed and saved, and any excess of gas is also condensed.

As soon as the decomposition is complete the fluids in chambers 1, 2, 3 and 4 are drawn off into the vats, and the residue containing the insoluble matter, having been first washed with water admitted from the reservoir 7, is dumped into the car 30.

At the same time the plug 37 is removed and the stop cock 35 opened.

The noxious gases and fumes in the upper part of the chambers 1, 2, 3 and 4 are then drawn off, and pass through the pipe 9, into the acid containing chambers 5, where they are condensed.

While this apparatus is especially adapted to the treatment of sulphides, it may also be employed with almost any ores, except those containing a high percentage of iron, or those so intimately mixed with calcium as not to permit of ready and inexpensive sorting.

As this apparatus may be employed with a variety of ores, in which the details of the process would naturally vary according to the ore being treated, it will not be advisable to enter into the details of the carrying out of the process with any particular ores. It may be said, however, that the acids employed will usually be nitric and hydrochloric in the proportion of thirty per cent. acid to seventy per cent. water.

Mixtures of these acids, or other acids, might, in some cases, be employed, according to circumstances.

The quantity of acid employed will, of course, depend on the proportion of the metallic contents of the ores treated.

If nitric acid be employed, as the result of more or less complicated actions and re-actions, nitrogen tetroxide would

be formed in a gaseous state. This, by combination with the water of the dilute acid, is decomposed and forms nitric and nitrous acid, causing the ore to be exposed to the action of the acid in a nascent state, thus greatly increasing the energy of the re-action.

A certain proportion of the nitrogen tetroxide will also pass on into the reservoirs filled with water, and will there be converted into nitric and nitrous acid, and absorbed.

By the aeration of the solution the nitrous acid can be converted into nitric acid, but it may be pointed out that a certain amount of nitrous acid in the nitric acid appears to materially assist the latter in its action.

If hydrochloric acid be employed, as would be the case with some ores, the re-actions would be somewhat different, but in the main features the processes will be substantially the same, except that the condensation of the gases in the tanks 5 will probably result in the formation of the hydrochloric acid, which may be used again with the next charge.

It will be seen that with this apparatus a process which is cyclic in its nature will be carried on, that is, all the gaseous products of each chemical re-action are sent through the successive ore chambers and the gases finally condensed in the chambers containing water to form or dilute acid ready for use with a new charge.

THE BED-ROCK OF THE GILBERT RIVER GOLD-FIELDS, QUEBEC.

By John A. Dresser, M.A., St. Henri de Montreal, Que.

(Published by permission of the Acting-Director of the Geological Survey of Canada.)

The gold hitherto produced in the Province of Quebec has been taken principally from the placer deposits of the Chaudiere basin in the County of Beauce. The important deposits have been found not in the valley of the Chaudiere itself, but along its tributaries, especially the Famine, Du Loup, Gilbert and Des Plantes. Of these, the Gilbert is probably the best known. All have been described at various times in the reports of the Geological Survey, particularly by Michel, Ells, and Chalmers.

It has been thought by all investigators, as far as could be ascertained, that the source of the gold is in the underlying rock, or in that of the immediate neighborhood. The bed-rock has been often described as noted for its decomposed condition and quartzose character, and in all cases has been considered to be an altered sediment.

Michel pointed out in 1866 that gold occurs in important amounts on the Gilbert, only within a quite definite area, and this opinion has been corroborated by the observation of subsequent workers. The extent of the gravels thus far known to produce gold, as pointed out to the writer last summer by Jerome Carillon, foreman of the Gilbert River Goldfields Co., coincides very closely with those indicated by Michel. Within this area, exposures of the bed-rock are rare. In the channel of the Gilbert River, however, near the Gilbert River Gold Mines post office, which is about the centre of this area, an accessible exposure occurs, and specimens of a similar rock are brought up from the deep diggings in which the gold is found. This rock is a variety of porphyry, a volcanic rock of the same class that underlies the gold-bearing gravels in Dudswell in the County of Wolfe, and which is the country

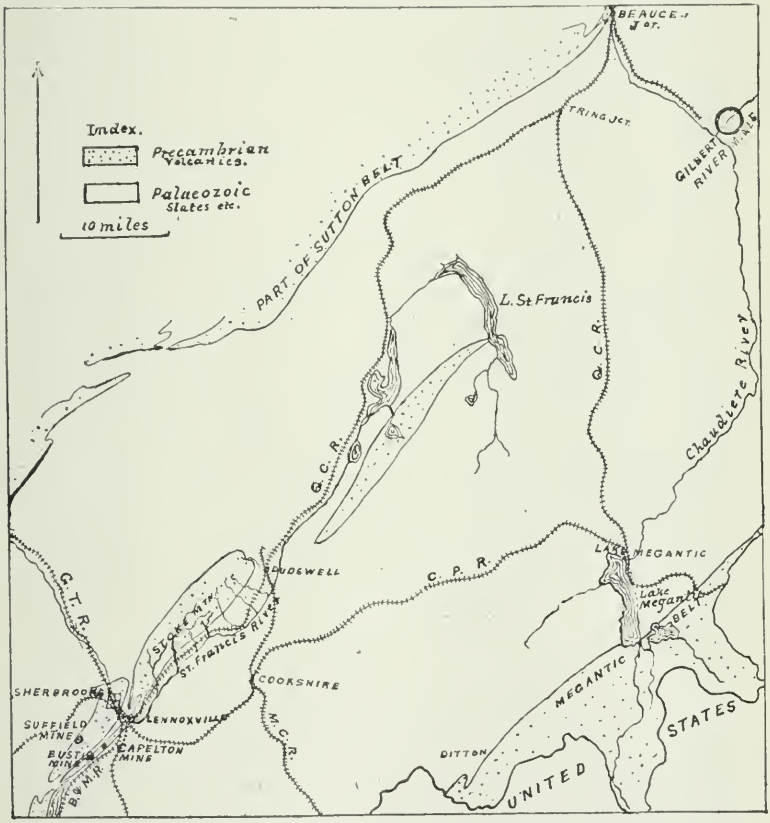
rock of the well-known copper lodes at Eustis, Suffield and Capelton, in the township of Ascot, near Sherbrooke.

The latter is the rock of the mineralized belt which extends from Lake Memphremagog to Lake St. Francis, and includes the mines at Capelton, Eustis, Suffield and other parts of the township of Ascot, as well as portions of Stoke and Weedon. It has yielded the greater part of the copper thus far produced in the Province of Quebec. Similar rocks form a longer and larger area, known as the Sutton mountain belt, some twenty-five miles farther to the northwest, and also occupy a third large area along the boundary of the State of Maine, in the vicinity of Lake Megantic. The extent of the last mentioned occurrence is not yet at all definitely known. The volcanics in the Gilbert River area are thus some fifty miles northwest of those at Lake Megantic, and thirty miles northeast of the similar rocks of the Ascot belt at Lake St. Francis. The latter have hitherto been supposed to end at that point, but, from the agreement of the rocks of the Gilbert River in position, and also in petrographical character, with the rocks of the Ascot belt, they appear to be a continuation of that group.

The rocks of the Ascot and the Sutton belts belong to the porphyry-andesite series of volcanics, and seem to be frequently more acid in the vicinity of the copper deposits. They are in all cases extremely crushed, sheared and otherwise altered, and in consequence their original volcanic character has only recently been discovered. The ores which they contain are yellow, gray and purple copper, with green and blue carbonates. They frequently carry important amounts of gold, and, sometimes, of silver. Placer gold is also found in the gravels of many of the streams running over this rock, of which the best known are the Kingsley, Big Hollow, Rowe's, Willard's and Hall's Brooks on the south side of Stoke Mountain, in the township of Dudswell.

An interesting parallel to the relations of the gold-bearing to the other rocks, as presented on the Gilbert River, was pointed out to me by Mr. John Blue, manager at the Eustis

Copper Mines. Here a hill, 700 feet high, is composed of a ridge of volcanic rock 500 feet in height, capped by 200 feet of sediments. Gold occurs along the little brook which runs down the hill near the mine, both in the gravel and in quartz



Index Map showing the relative position of the volcanic copper belts and placer gold deposits in the Eastern Townships of Quebec.

veins, up to the limit of the volcanic rock, above which none has been found. This seems to represent in miniature the conditions at the Gilbert River.

The Capelton-Eustis properties were originally developed as a gold property, but the percentage of gold declined as lower levels were reached, while the amount of copper greatly increased. Yet gold is still a factor of appreciable value in many of these ores. It is also worthy of note that the gravels of the St. Francis River carry small amounts of gold between Lennoxville and Sherbrooke, and also at Melbourne. In the former locality the river crosses the copper-bearing volcanics of the Ascot belt, and at the latter, it crosses the Sutton band, which is of similar character, and receives the discharge of some smaller streams which flow over those rocks.

On the whole, the conclusion seems to be justifiable that the placer gold of southeastern Quebec may in all cases be derived from the same series of volcanic rocks that contains the principal copper deposits of the region. Hence, it would follow that alluvial gold in this region should be looked for only in localities underlain by these volcanics, or in lower parts of the valleys of the streams which traverse, or have traversed, them; and that it may occur in any part of the area occupied by these rocks in which the conditions have been favorable to the formation and preservation of placer deposits. The occurrence of gold seems, at all events, to be a reliable indication of the proximity of copper-bearing rocks, in this district.

DISCUSSION.

Mr. Dresser, referring to the 6th paragraph of his paper—But, if I remember correctly, Mr. Blue has estimated the total amount of gold at some two million dollars, and that as upon the number of these fields that have been worked."

Mr. Dresser's remark on paragraph 7 of paper:—"In fact, the only producing copper mines not within these belts would be the now exhausted Acton mines and Huntingdon mines."

I may add that it is particularly fortunate that at the moment of presenting this paper we have with us Mr. Blue

and Mr. Hardman, both of whom have had experience in this district. I may add another point, which did not occur to me when writing this short note. I believe that many year ago prospecting was carried on in the district of Lambton, which lies between Lake St. Francis and the Gilbert River district.

The President—Mr. Dresser has brought forward some very interesting points in connection with the gold and copper districts of the Eastern Townships. I would like to hear from Mr. Blue, who is so well informed on the subject of that copper district. I would also ask him concerning the statement relating to the Capelton mines, which were first operated for gold. How long were they worked for this metal? and was the recovery of gold of much importance at first?

Mr. Blue—In Mr. Dresser's paper there are a great many statements that are perfectly correct, but there are others to which I take exception. Mr. Dresser is mistaken in stating that our mines were first operated as gold mines. They were established copper mines long before I became connected with the district; still, it is a well-known fact that a certain quantity of gold accompanies all the copper-bearing rocks in our district; but this does not apply everywhere. In the first section of his paper Mr. Dresser gives a description of the River du Loup and other tributary streams, and of course there is some gold there, but no copper that I am aware of. It may be that the rocks of the Gilbert are of the same character as our rocks in the Eustis belt; but the rocks in the River du Loup, consisting of the Cambrian, schists and quartz veins are very different. I know of no copper in that district, so I think Mr. Dresser has made a mistake in stating that where gold occurs there you will find copper. You can find gold in the gravels of many of the little streams, and all through the country rock veins and pockets of quartz occur, some of them carrying gold, but in most cases in too small quantities to make them of commercial value.

Mr. Dresser—Might I say that Mr. Blue has not quite understood me. When I said that the properties were first

operated as gold mines, it was not my meaning that they had ever been actually worked as such alone, but that they had once changed hands as gold properties. It was found afterwards that it was only on account of the other associated minerals, copper and sulphur, that these deposits were capable of profitable operation. In the first assays the gold values were very important, but upon further development the properties did not fulfill original expectations in this regard. However, the titles to the property, fortunately for the holders, included all minerals, and the copper mines were developed in consequence. It was in that sense that I spoke of the Capelton-Eustis properties having been originally gold mines. Placer gold, too, is an indication of the amount of copper in this district. It does not follow that the placer gold will always rest upon the copper rock, but the occurrence of the latter is at least to be looked for near by. The fact I regard as of chief importance, is that in this gold-bearing area defined by Mickel, it has been found that the bedrock is of the same volcanic type which characterizes the copper-bearing localities, and that going outside of this area the rock is a sedimentary slate of an altogether different quality.

Mr. Hardman—I, perhaps, will have the opportunity of giving a written opinion on this paper, but if Mr. Dresser states that such plutonic rocks are usually copper-bearing, then I think I shall have to disagree with him. On the east side of the lake there are some deposits which have been worked, but not for copper. I am quite sure Mr. Dresser will not find any out-layers to the north of the lake.

Mr. Dresser—They scarcely reach the lake.

Mr. Hardman—Last year, in October or November, I was retained to visit the southwest side of Magog River. There are a number of small streams running into the Magog that have been sufficiently auriferous to enable individual miners to extract from $1.00 to $1.50 per day. The country rock here certainly showed no indication of volcanic origin, although that is very close to the eruptives about ten miles distant, in the vicinity of Mr. Blue's property. I would like

to add that it is small wonder to me that the Geological Survey on the one hand, and practical men on the other, do not realize the economic mining possibilities of the Province of Quebec. A great deal of attention has been given to the resources of British Columbia, Ontario and Nova Scotia, but such a paper as Mr. Dresser's will give members of the Institute a better idea of the Quebec metals. I think that the Province of Quebec, two hundred miles north of Lake St. John, will certainly in the next ten years make a better showing in respect to mineral production.

Mr. Dresser—The statement of my paper is that the placer gold is an indication of the presence of volcanic rock, and the chief copper mines in the locality are found in the same volcanic rock.

The President—I have another question to ask of Mr. Blue in reference to the gold now to be met with in the copper veins of the Capelton mines. Is there an appreciable quantity of gold in these ores, or sufficient quantity to admit of it being saved?

Mr. Blue—The value of the gold is about twenty-five cents per ton of ore.

Mr. Mills—I would call attention to the fact that on the north shore of the Georgian Bay, eastward from Bruce mines, the copper is invariably accompanied with gold. It varies from fifty cents to as high as $6.00 per ton. Those deposits with which I am best acquainted are in the neighborhood of Ironbridge, Ont. At one property there, the samples assayed from fifty cents to $2.60 per ton, with 4 to 6 per cent. copper. This seems to be the rule all through that section of the country.

Dr. Goodwin—There is at Parry Sound an opening which was worked as a gold mine, and about a stone's throw distant another property was worked for copper.

Mr. Hardman—I may say that I went up to see the Parry Sound gold mine, and I found it far more valuable as a copper mine, there being better values in copper than in gold.

Mr. Blue—Gold is not always associated with copper. West of Sudbury, some fifty or one hundred miles distant, there are four or five copper mines, but none of them contain any gold values.

Mr. Ingall—I do not think that they ever recognized gold in the old Bruce mines, nor do I fancy that we shall ever find it there.

The President—The principal points brought out by Mr. Dresser have been well emphasized, that the bedrocks in the Gilbert River goldfield are the same as the bedrocks in the copper belts of the Eastern Townships.

A NOTE ON VARIETIES OF SERPENTINE IN SOUTH-EASTERN QUEBEC.

By John A. Dresser, M.A., St. Henri de Montreal, Que.

The importance of the asbestos and the chromic iron industries makes any information regarding the serpentine rocks, in which these minerals occur, of more than mere scientific interest. The serpentine belt in the Eastern Townships has contributed a generous share to the mineral wealth of Canada, and is likely to continue to do so for many years to come. Yet the rocks composing it have received less scientific study than might have been expected from their practical importance, in fact, very much less than some other geological formations in the same region which have little, if any, economic interest whatever.

This short paper embodies a few incomplete observations on the serpentine, and is presented with the view of gathering further information necessary to give them greater precision and practical utility.

Serpentine is a metamorphic rock, being in all cases produced by the alteration of some earlier rock or rocks rich in iron-magnesia minerals. These have generally been so far altered that it is difficult, if not impossible, to determine what their original characters really were. In the early days of the Canadian Geological Survey the serpentines of Quebec received considerable attention, chiefly from the late Dr. Sterry Hunt. By the study of their chemical characters he was led to believe, in accordance with the prevailing geological theories of that time, that the serpentines had been formed from magnesian limestones. This view has since been disproved by Dr. F. D. Adams, who has shown from miscroscopic evidence that the serpentine in many parts of Quebec have been derived from a rock of the peridotite class. These very basic rocks are composed of silicates of magnesium and iron, olivine and pyroxene being the chief mineral constituents. They have solidified from a molten lava slowly

and at very considerable depth, and hence have a coarse grain, or texture. By extensive alteration, especially hydration, peridotites which are rich in olivine become serpentines. Similarly those rocks in which pyroxene was originally more abundant than olivine, the pyroxenites, have become the talc masses which are common in the same district. This view of their source, being in agreement with the well known origin of serpentines in many other parts of the world, has been generally accepted for all the serpentines of south-eastern Quebec.

In the course of the past summer some bodies of serpentine have been observed by the writer which seem to show a somewhat different origin, and which, therefore, indicate that we have at least two distinct varieties of that important rock in the same region. A typical occurrence of these is that found in lot 21 in ranges III and IV of the township of Ham, in the county of Wolfe, and is situated about a mile and a half from the village of North Ham. The country rock here is a gray, or greenish gray, slate, a rock common in the hilly country to the north-west of the main serpentine belt. It is indicated on the geological survey maps as being of Precambrian age, and, like the serpentine, extends in a north-east south-westerly direction, with few intervals, from the Vermont boundary line to the vicinity of the Chaudiere river. In this and similar localities this rock is found to change within a distance of a few feet, not exceeding twenty, from a gray slate to serpentine. Excavations made for asbestos in the serpentine of the above mentioned property clearly show that there has been no volcanic intrusion, fault or other disturbance to break the continuity of the rock mass. A microscopic examination of the slate shows it to be a much altered volcanic rock, a variety of porphyrite. The serpentine would, therefore, seem to be an alteration product of some very basic phase of this rock, which has been quite sharply separated from the rest, while the whole was in the process of cooling from a molten state. The cooling has doubtless taken place more quickly, and under less pressure, in the case of the porphyrite, than of the peridotite. The basic phase might have been an olivine diabase, especially rich in olivine or an effusive rock corresponding yet more closely

to peridotite in chemical composition, but agreeing more nearly with the porphyrite in structure. A picrite porphyrite would be such a rock.

In the field such occurrences of serpentine are distinguished from others by their seeming to pass almost insensibly from serpentine to a slate, which by the unaided eye, cannot, in general, be distinguished from a sedimentary rock. The serpentine in the locality cited, carries a little asbestos of poor quality and of which the fibre is not more than one-sixteenth of an inch in length. Apparently similar occurrences of serpentine were also observed in the townships of Leeds and Broughton.

The importance of these areas, as far as can now be judged, is not in their own value, but in the evidence they furnish, that there are at least two classes of serpentine quite different in origin, and probably also in age.

How large a part of the Quebec serpentines belong to each type, and whether they are both valuable as sources of asbestos, are the two practical questions involved. The most important asbestos mines now in operation in Quebec are located on the peridotite serpentine, while unsuccessful prospects are numerous in both. Accordingly, in exploration for asbestos the variety of the serpentine would appear to be an important factor and one of the first to be investigated.

DISCUSSION.

Mr. Dresser—I may say that I have presented this paper merely with a view of ascertaining whether there are fruitful and important asbestos deposits in this second class of serpentine, or whether it is not to be regarded as an ore-bearing rock.

The President—You do not know of any mines of asbestos in this second class of serpentine?

Mr. Dresser—None that have been successful that I have seen.

The President—Is the asbestos short fibre?

Mr. Dresser—Yes; a short fibre not exceeding a quarter of an inch.

The President—Is it good?

Mr. Dresser—None that seems especially good.

The President—Is it your opinion that any successful operations could be carried on in that formation?

Mr. Dresser—That is what I would like to find out. Considerable sums of money have been expended, which might have been saved could it have been proved that the mines were unproductive. It may be found yet that they will be productive in some places. The rock has not been examined in detail, and it is a matter concerning which we must gain information as far as possible. To the best of my knowledge, there is yet nothing but these small prospects.

The President—I think it is quite important that Mr. Dresser should bring this to the attention of the mining men of Quebec, that they may more closely examine this rock for asbestos.

Mr. Blue—Well; when it is there, it is there; and when it is not, it is not.

Mr. Dillon-Mills—Does fibrous serpentine occur in limestone, or is it always in the amorthous condition? I have invariably seen it in the latter form in Haliburton County.

Dr. Goodwin—At Long Lake, in Ontario, serpentine has been found closely associated with limestone, and some of it is fibrous. Small scales of molybdenite were found in the serpentine—a very curious form of molybdenite.

Mr. Hopper—Where you have asbestos you have otner minerals associated.

The President—In all these asbestos veins there is considerable magnetite, is there not?

Mr. Hopper—Magnetite or chromic iron?

Mr. Dresser—There are frequently in the asbestos veins other veins which prove to be chromic iron.

The President—Or magnetite?

Mr. Dresser—Yes; when this mineral divides the asbestos

vein in two short veins, instead of one longer one, the result is a commercial loss.

Mr. Blue—In a mine in the neighborhood of Little Bronton Lake, Mr. McCaw prospected for asbestos, which he discovered. In sinking a shaft he came to another kind of mineral, which was investigated, and proved to be chromic iron. He went still deeper and found another mineral, which was submitted to me. This was one of the finest specimens of copper ore imaginable: chalcocite carrying about 70 per cent. Cu. In one shaft of about 100 feet deep, three valuable minerals were found.

The President—It shows that all minerals are very closely allied, and in most cases allied with volcanic rock. It may be one, or it may be the other, within a distance of a few feet, as Mr. Blue has just stated.

"LOS REYES" GOLD MINES, SOUTHERN MEXICO.

By Alexander H. Smith.

Oaxaca is the most southerly of the Mexican states, with the exception of Chiapas, and is, roughly, the juncture of the Eastern and Western Sierra Madres which form the boundaries of the great Cordilleran Plateau, Province of Mexico. This merging of the two great mountain ranges produces a wild and beautiful jumble of mountains that, in places, have an elevation of over 10,000 feet. In the high altitudes these mountains have their sides covered with splendid timber: pine, oak, a species of ash and madrone. Few wide valleys of any extent occur except in the Southern part of the state on the Isthmus of Tehuantepec.

To the west of the city of Oaxaca, which lies in a beautiful wide valley at an altitude of some five thousand feet, the Western Sierra Madres rise, in places over ten thousand feet. The tops of these higher mountains are generally thickly wooded with pine and some hard woods that make fair timber for mining purposes and for building material, and, in these higher altitudes, during the winter months, roughly, from December to February, ice forms and quite severe frosts occur, although only seventeen degrees North latitude. These Western Sierra Madres strike in a North-westerly direction. A road, which in places is no better than a trail, runs westerly about thirty-two miles over San Pablo mountain (9,000 feet), and down into the canon of San Miguel Peras, where Los Reyes gold mines are situated at an elevation of 7,000 feet.

A short distance west of Oaxaca, on the road to San Miguel Peras, the first exposed rocks are met with and, from this point as far as the writer has been to the west, the formation is gneiss with a strike, roughly, north and south. The gneiss is composed of pink felspar (orthoclase), quartz, mica

and hornblende; in places fine-grained approaching a felsite in texture with two or more planes of cleavage. Then, again, it is pegmatitic in structure, masses of orthoclase, quartz and biotite mica forming roughly into a uniform body that appears like a dyke. Numerous quartz veins are to be seen striking north and south parallel to the strike of the gneiss. A few so-called porphyry dykes also cut through the gneiss, generally parallel with the strike of the formation. Another series of deposits, of crystalline limestone also occurs which have the appearance of veins. These, also, have a north and south strike. The limestone is rather peculiar and appears, in places, to be sedimentary in origin, having small, round pebbles of gneiss and the dark minerals of the formation. Scattered through it, are crystals of apatite, and small scales of graphite; on weathered surfaces, small nodules of hornblende and pebbles of other rocks have resisted the weathering and stand out, making the out-croppings appear like an altered part of the country rock. On fresh surfaces the limestone appears like a light-colored granite. These deposits carry traces of gold and silver.

The character of the formation of this district is similar to that in the Laurentian and Huronian districts of Ontario: Northern Peterborough county, for intance. The writer judges that it is Huronian. To the north of San Miguel Peras, at numerous points along the Mexican Southern R.R., gneiss, of the same character as described, is observed, capped with reddish conglomerates, sandstone, and argillaceous limestones. In a canon, about two miles to the west of San Miguel Peras, erratic blocks of conglomerate are strewn along the bottom. From these observed conglomerates, in one place lying directly on the gneiss, as noted on the Mexican Southern, many miles to the north of San Miguel Peras and, also, the boulders of conglomerate in the canon near by, it appears that the conglomerate formed, at one time, the capping of the gneiss.

In the San Miguel Peras district two sets of veins occur: those cutting the strike of the gneiss at nearly right angles (S. 80 deg. E.), and those with a north and south strike paral-

lel to the formation and with a perpendicular dip. These north and south veins do not carry values as far as has been determined up to date. Considerable work has been done in several places, but barren of results except in traces of gold and one or two ounces of silver to the ton. Some of these north and south veins, and especially one locally called the "Veta Madre," outcrops for many miles across country. This "Veta Madre," which cuts the San Rafael vein of the Los Reyes Company, and, at that point, a little over one foot wide, is over sixty feet wide in places, composed of strong looking quartz, well mineralized with iron sulphides, but, even in the most likely-looking samples the values are only a trace.

Turning to the east and west veins, although similar in appearance (that is, quartz veins containing considerable iron sulphides), silver is practically absent, the gold running as high as 960 fine. This system of veins has been proved to be the only one carrying values of economic importance. In the immediate vicinity of San Miguel Peras, three sets of veins are located on three mountains which lie in a line in a north-easterly direction. The Montana veins, of the north-east mountain, dip nearly vertically to the north. The San Rafael on the middle mountain dip 32 deg. with a strike south, 80 deg. east and Los Reyes veins are practically flat, with an average dip of about 20 deg. south, 20 deg. west. These three sets of veins have been worked for many years; in fact, it is believed that they were worked before the time of Cortez and the Spanish Conquest. Undoubtedly they were worked by the Spaniards, and, in some places, the headings must have been driven by heating the rock, and, then pouring water on it. This form of mining must have been terribly severe on the workers, especially where the workings were any distance from the surface. However, labour was evidently plentiful and cost nothing, as peonage, to a high degree of perfection, was practiced. Labour costing next to nothing, and time evidently not counted in getting results naturally meant that very low-grade ore could be mined, and it is the writer's firm belief that this was the case all over Mexico, and if an ore was

tractible by any of the old methods furnace, amalgamation (patio and otherwise); if a fairly dry mine carried any values, say above $5.00 gold a ton, that mine was well worked, and the general belief that old mines, "antiques," offer splendid chances under modern methods is not well founded. Mexico is full of old mines, shells, but in these old mines everything over five dollars has been taken out. This is especially true in regard to silver and gold ores. Where the ore was fairly rebellious under old methods, or the mine exceptionally hard to work, due to water or hardness of rock and depth of workings, good chances are to be found in these "antiques."

Los Reyes mines were certainly worked in the beginning of the last century and for forty years by a certain Don Wenceslao Garcia, till purchased by the present company in the spring of 1901. Garcia treated the ore in arrastras, run by horizontal wooden water-wheels; the water running down a steep flume and striking against the fans of the wheel. Eighteen arrastras were employed at one time, the arrastras being eleven feet in diameter, the wheel to drive the mullers being sixteen feet in diameter. That these old arrastras were not good gold savers is abundantly proved by huge heaps of old tailings scattered around Los Reyes hacienda, these tailings assaying from $6.00 gold a ton to $30.00 gold. Although amalgamation was practiced directly, still, a great deal of the ore was treated in the arrastras to form concentrates alone, the gold in the concentrates being amalgamated by treating in wooden bowls, a wooden riffle being placed below the bowls to catch amalgam washed over with the tailings. Where pyritic ore was treated with mercury in the arrastras, the loss of gold, amalgam and quicksilver must have been enormous. This loss was counteracted, to a certain extent, by a liberal addition of lime; the lime being added till the whole charge in the arrastras foamed up to the top. Here was an old Mexican mine that had good prospects of a brilliant future under modern methods, a good supply of rich ore in sight, good evidence of former riches proved by these huge piles of tailings that average over $12.00 gold per ton, and the knowledge

that certain tunnels or adits being driven, no trouble from water need be experienced. Under these circumstances the present company took over the property from Senor Garcia in 1901; the writer taking the position as mining engineer at the beginning, and, later on, being appointed manager.

The property of Los Reyes Gold Mining and Milling Company consists of two groups of mines: San Rafael on the middle Mountain as shown in the sketch, and Los Reyes.

On San Rafael mountain two parallel veins are known, but only one is worked. The vein varies in width from eight inches to nine feet. It is worked by a cross-cut tunnel of 160 meters. As all above, where this tunnel cuts the vein, has been worked out, the vein is worked by inclines or winzes, the ore being hauled to the tunnel level and handled by cars to the surface. The vein filling is quartz of various colors, white, glassy-blue and brown. In places it is heavily mineralized with iron sulphides, pyrrhotite, marcasite, iron pyrite and a small amount of arsenopyrite. Occasionally traces of copper pyrite are encountered, but very seldom. Where iron pyrite occurs the vein has a ribboned structure, but where the pyrrhotite is found, quartz and sulphides are in masses. The pyrrhotite forms in pure masses, but, generally, is mixed with iron pyrites and small pieces of quartz. Both quartz and iron pyrites occur as crystals in this pyrrhotite, the pyrite forming in beautiful foliated or cubical structures with green or purplish-green and bronzy colors. Where much sulphides are encountered the values are good, the solid pyrrhotite often running three or four ounces to the ton. Numerous fault fractures occur, which has led to considerable oxidization and leaching-out of the sulphides and also, to a considerable extent, of the values. Along these fractures are numerous vuggs filled with iron oxides and, sometimes, druzy quartz. Cases are known where this iron oxide has been exceptionally rich, but, as a rule, it only carries traces of gold. These areas of oxidization along the fault fissures have no width and fade almost immediately into unoxidized ore. The gold appears to be absolutely free, but in very fine particles and

only occasionally to be seen as "specimen rock." The massive pyrrhotite sometimes shows free gold on panning, but, as a rule, no gold is visible even after roasting and grinding before panning. That this pyritic ore is free-milling has been abundantly proved by over three years practice, and, even when no gold is seen in panning, the ore, if properly mixed with quartz gives a saving of over seventy-five per cent. by amalgamation.

Los Reyes group of mines are situated on the third or southern mountain. This mountain is like a huge layer cake, seven veins, one below the other, almost horizontal, being known. The mountain rises 1,400 feet above the bottom of the canon. The strike as mentioned above is N. 20 deg. E., with an average dip of 20 deg. S. Numerous faults, generally east and west, occur; the veins being by no means regular in the angle of dip, but having numerous waves or folds. These changes of dip, and the occurence of faults present numerous difficulties to the engineer and give him a decidedly tricky and baffling problem to solve, especially when locating and running adits for cars and developing the mine with a view to the greatest economy. A glance at the working plans show many curious turns and twists to drifts designed for car levels.

In the upper veins the vein-filling is quartz, generally mineralized with iron pyrites and marcasite. A little pyrrhotite and calcite is seen and some copper pyrite, very low in copper. The lower veins in the mountain have considerably more pyrrhotite, in places solid masses occurring extending many feet along the vein. The values, as a general rule, are associated with the mineralized part of the vein, but iron-stained quartz and where the vein filling is decomposed, are also good indications of values. However, the most unpromising white glassy-quartz, sometimes made up of crystals and coated with a fine film of black oxide of manganese also carry values. Bodies of ore comprising three or four hundred tons are found that are simply masses of cubical pyrites, associated with calcite and crystals of quartz. These masses are exceedingly rich and also very free-milling, even when treat-

ed in the mill without mixing with quartzy ore. All the veins in the two groups of mines are opened up by tunnels or adits, the outlines of the mountains and the dip of veins giving excellent facilities for this purpose. On the Los Reyes' side the whole method is summed up in three words: "Follow the ore." The amount of work done, in former days, on the upper two veins, which are the principal ones and only separated by a few meters of rock, was tremendous. Here the principal of following the ore was carried to the extreme. Miles and miles of low, narrow drifts, winzes and upraises make a regular maze of the old workings. No attempts were made to drive levels, and the practice seems to have been to follow the pay no matter if it led up or down or required the running of parallel workings a few meters apart. When the present company took over the mines it was known that rich pillars and bodies of ore were left in these old workings, ore that it did not pay to treat by arrastras. It is certain that not one-half of this could have been profitably recovered if this mine were situated in the United States or Canada. Here, however, these workings have produced, on an average, over three hundred tons a month for nearly four years, and ore that paid a handsome profit. The whole of the old workings have been worked on the "buscone" system. The miners, on Mondays, buy from the company dynamite, fuse, caps and candles; the company supplying tools, such as wooden shovels and "chiquihuites," or wicker baskets of about 125 lbs. capacity in broken ore. On receiving their supplies the busconers, as the name implies, enter the mine, generally in pairs, and hunt for ore. When all have places the faces are measured up and prices given ranging from $1.60 to $8.00 Mex. per metric ton, delivered on the patio outside. The ore, in places, is very narrow, sometimes only four inches and, besides, the rock is often very hard. As these narrow strips are generally very rich it pays to work them at these prices. For these places $8.00 Mex. is paid. As all of this ore of the busconers has to be packed out in baskets, sometimes over 500 meters through low workings and up steep inclines, where the vein has pitch-

ed or faulted, the prices mentioned per ton are exceedingly low. The only difficulty experienced in this buscone method is to keep track of where the faces are, which involves crawling, sometimes, on one's belly for hundreds of feet to a place where the candles burn low on account of foul air, to where one finds the miners busily at work carrying in a one-foot breast to take out a stringer of ore, perhaps only six inches in width and through the hardest and toughest of gneiss. At first it was deemed advisable to make these busconers carry in high breasts. It was also thought that they should be supplied with iron shovels, but the cost and difficulties soon proved that, in this case at least, modern mine practice was distinctly at fault. Owing to its nature, a simple method of finding out the values of the ore on which the busconers are working is practiced. Samples are taken from the working faces, and, if not too heavily mineralized, these samples are ground down and panned in a small porcelain bowl, about six inches in diameter at the top and glazed dark-green inside. These pannings called "tinta duras," give remarkably close results as to the value of the ore, and the average Mexican is very expert in the handling of these small dishes; working down all of the pulp to about a sixteenth of a teaspoonful in a few minutes, and saving all of the gold. Again, modern methods were attempted in this case, pans and horn-spoons to take the place of "porcelanas," but were quickly abandoned, even by men used to the gold pan, in favour of the small dish. Of course, doubtful or heavily-mineralized samples are sent to the assay office for checking purposes, but in over three years of practice the value of these pannings has been abundantly proved successful as a quick and sure guide in controlling the work of the busconers.

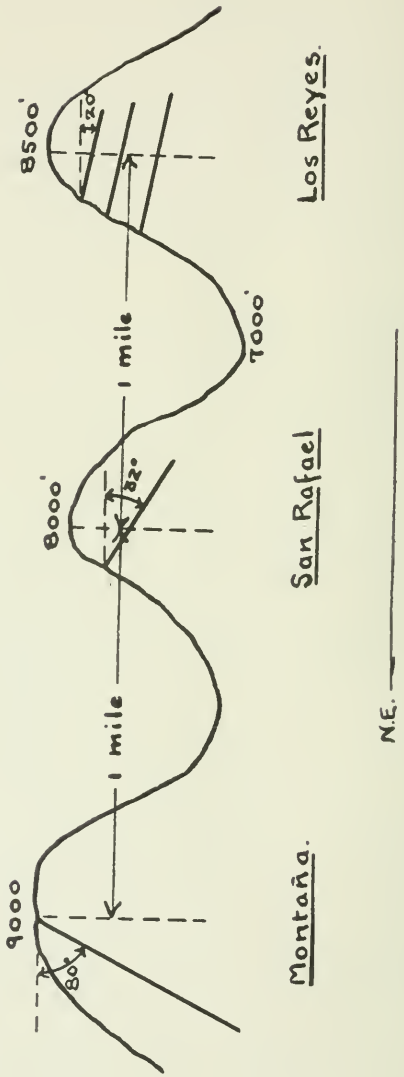
In the new work done by the present company adits and drifts are run below the old workings so that the ore and waste can be more economically handled. The different headings are contracted, the prices ranging from $10.00 to $40.00 a meter, Mex. currency. This work is slow, but the general progress has improved wonderfully under the competent direction of

foreign foremen. The miners have been educated for a three-pound hammer with a one-foot handle, and sitting down to their work to a seven or eight pound hammer with a long handle. They can, now, put in back holes in the face of a drift, and know the value of long holes and are using some thought as to the placing of their shots. In most of the drifts, even with the advantage of blasting to the vein and thus profiting by the "relise," the gneiss proves hard to drill and extremely tricky in breaking, high grade explosives of sixty or seventy-five per cent. have to be used. The character of the formation and the difficulty of getting good, steady labour for work of this description is accountable for the slowness. As the work progresses along the vein the ore exposed is let out by contract at so much per ton, the price being regulated by the width of the vein, hardness of rock and distance from the entrance.

On account of the formation of the gneiss being on edge, very little timber has to be used and stopes can be carried considerable distance with only an occasional stull, but, in the new workings, the waste is filled in as the stoping progresses. Of course, the entrances have to be well timbered as the formation in places is heavy to considerable depths. A watch has to be placed on the miners to see that they do not carry stopes to too great a distance without supporting the roof; they will insist upon working in dangerous places. However, this does not appear to be of vital importance, judging from the fact that for nearly four years and with an average of two hundred men working, not a single serious accident has occurred; this, in spite of the fact, that a great number of inexperienced men and boys are employed, the economy that they practice in the use of fuse, the contractors and busconers using short fuse—sometimes not six inches long and having often to crawl long distances before getting protection from the blast—and the trouble experienced in teaching some of them that it was not necessary to warm the "fulminates" over the candle flame before using, and that a lighted cigarette was not a safe thing to place on their supply-bag of dynamite and caps.

Owing to the situation of the mines and the impossibilities presented at present, no economic method has been adopted of delivering ore to the mill, which is situated at the bottom of the canon, 1,200 feet below Los Reyes and about two miles distant by road, and about the same distance from San Rafael, which is about 800 feet higher than the mill. In spite of distance from the mill and rough, steep roads for freighting over, the ore is delivered for from eighty cents to ninety-five cents gold a metric ton by pack-animals, mules, horses and "burros." The prices are, under the circumstances, remarkably low.

For the purpose of treating the ore, a twenty-stamp mill (850 lbs.) Allis-Chalmers, is situated at the bottom of the canon, roughly, half way between Los Reyes and San Rafael mines. Abundant water power is developed, from a creek that runs through the canon, to operate the twenty stamps and accessory machinery; also, to run a 50 kw. generator that supplies current for a 30 h.p. motor-driven air compressor for power drills and that supplies power for an electric pump and electric lighting for the plant. The ore is particularly amenable to amalgamation, and extractions as high as ninety per cent. have been made. Both inside and outside plates are used, over sixty-six per cent. of the values being recovered inside the mortars. If proper care is exercised to keep the percentage of pyrites low, say ten per cent, extraction of over eighty per cent. is assured. It is not on account of the pyrites not being free-milling, but the difficulty of keeping the plates bright; the pyrrhotite in particular being apt to slime considerably. This slime coats the plates, making them less sensitive, and, consequently, a loss of values occurs. By proper mixing with quartzy ore, sliming of the sulphides is not so serious, and the plates are kept in better condition. Still, runs have been made on ore carrying over twenty-five per cent. of sulphides and giving a saving of over seventy-five per cent. Lime is used with good effect in treating these heavy ores, also, the plates are dressed occasionally with a weak cyanide solution.


8500'
120°
7000'
1 mile
8000'
82°
1 mile
9000
80°
Los Reyes.
San Rafael
Montaña.
N.E.

For the purpose of retreating a very large accumulation of old tailings, part from the arrastras and part from the stamp-mill, a cyanide plant is being installed. As the tailings oxidize very quickly, especially the marcasite and pyrrhotite present, they are heavily charged with acids and salts, detrimental to the process. Also, the arrastra tailings are, by no means, regular in size—seventy-five per cent. passing 100—mesh screen and the remainder, twenty-five per cent. or sands ranging from pieces of quartz as large as a walnut down to what will remain on 100-mesh. A great deal of organic matter is present, chips from the side of the arrastra, etc. To prepare these arrastra tailings, a five-foot amalgamation-pan will be used. This plan disintegrating the tailings which are, as a rule, very fine and like clay. The chips and organic matter will float to the top, where it will be skimmed off from the pan. The discharge goes to a Richards, three-vortex classifier; the sands passing to a Huntington, and the slimes direct to slime vats. The slimes will be treated, first, to thorough washing, with air agitation, decantation, agitation with lime and, finally, with cyanide solution. For this purpose six 22-ft. x 6 ft. tanks will be used, each tank taking only a thirty-ton charge. The tailings from the mill will be run direct through classifiers, the sands being treated in special leaching vats; the slimes running to the slimes plant. From experience, these fresh sands are very amenable to the cyanide process, sands containing over twenty-five per cent. sulphides giving extractions of ninety-five per cent. on a four-days' treatment. A large accumulation of concentrates, however, will have to be roasted first, before cyanidation. Experiments show that ninety per cent. and over can be recovered with short treatment and with a low consumption of cyanide.

This, roughly, is a brief description of one of the few really free-milling gold mines of Mexico. El Oro is a large producer, but considerable of the values of that district are in silver, and amalgamation in one of the large mills, at least, is not practiced, and, to the knowledge of the writer, the district of San

Miguel Peras is about the only one, where ore is mined and milled for its gold values alone, in Mexico.

As indicated above, in numerous places, methods of mining, determining values and transportation are decidedly antediluvian at first sight, but their adoption, or rather their not being changed, is fully warranted by conditions and by comparison of cost sheets which are, certainly, in favour of a certain number of old methods.

INDICATOR CARDS.

By W. D. L. Hardie.

In view of the fact that compressed air machinery is becoming an ever-increasing part of the equipment of an up-to-date colliery, the writer thought that a short paper on the indicator card might at least be interesting, more especially that part of it which is the result of the writer's practical observations.

The indicator card, taken from the steam end of engines, is pretty well understood, and the writer will not devote much time to it, but the air end card has not come under the keen observation of such a large number and will, therefore, receive our attention.

In dealing with this subject perhaps the best plan will be to first give an ideal card from the air end, explaining the significance of the various lines and points, and, afterwards, compare cards, recently taken from compressors in present use, with it. In Fig. 1 the meaning of the lines are made plain by the designation words and the significance of the points designated by letters will now be explained. The atmosphere line is drawn on the card by the indicator pencil before the air is admitted into the indicator from the steam cylinder. The gauge pressure line is drawn, by hand, parallel to the atmospheric line at a distance above it, represented by the pressure shown on the receiver gauge at the time the card is taken.

The vacuum, during suction, may vary from nothing to two pounds. A heavy wave at the beginning of the suction line is due largely to the inertia of the indicator parts. In a compressor fitted with poppet valves having springs to close them there must be a vacuum in the cylinder sufficient to overcome the springs and suck the valves open. The valves

might vibrate a few times before setting and give a wavy first part of the suction line.

The Figs. have been considerably reduced from the size of the original without the scale being proportionately increased.

In any case, the piston must travel the distance A—B before the atmosphere line is reached, which means a loss in volume, making a larger allowance for clearance necessary than would be required if the drop were not on the line. A is the commencement of the stroke, but the piston must travel back on the return stroke as far as B before the air is at atmospheric pressure. B is, therefore, the beginning of the compression line.

C is the point at which compression would cease and the discharge begin were it not for the inertia of the valves, but to overcome this, the pressure rises considerably above this line, as will be seen by looking at this line on the several cards in this paper.

E is where the discharge is completed and the expansion begins.

F shows the point where expansion should discontinue and the suction begin.

Should the suction line rise above the atmospheric line, as it does in some of the accompanying cards, it would indicate a greater pressure in the cylinder than outside, which could be due only to a leaky valve.

If the discharge line rises more rapidly on one end of the cylinder than the other, and the point A on both ends is the same, the inference is that either the inlet or discharge valve is leaky. When everything is in proper working order in the air end the compression line on both ends of cylinder should cross each other precisely in the centre of the card. However, a slight variation is not looked upon with much suspicion, and sometimes had better be put up with than go to the trouble and expense that would be required to overcome the defect. This is more especially true if the compressor has been in service several years.

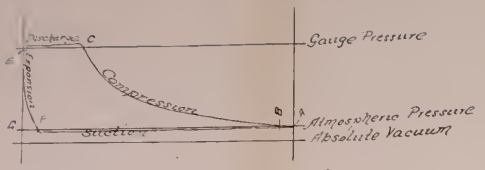

Suction
C
Gauge Pressure
Compression
B
A
Atmosphere Pressure
D
F
Absolute Vacuum

Fig. 1.

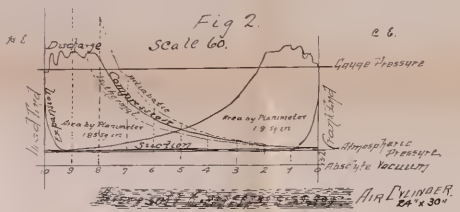


Fig 2.
Scale 60.
H.E.
C.E.
Discharge
Gauge Pressure
Compression
Area by Planimeter 1895 sq in
Area by Planimeter 1915 sq in
Suction
Atmospheric Pressure
Absolute Vacuum
AIR CYLINDER 24"x 30"

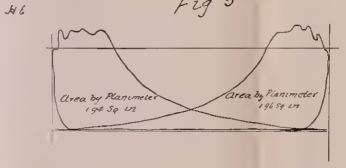


Fig 3
H.E.
C.E.
Area by Planimeter 1948 Sq in
Area by Planimeter 1967 Sq in

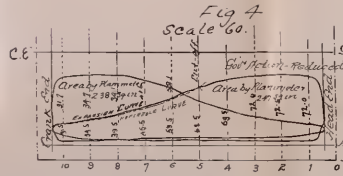
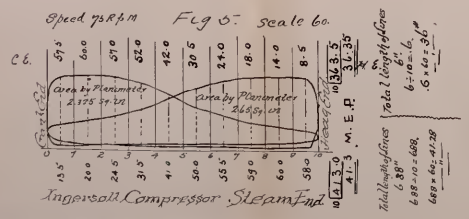
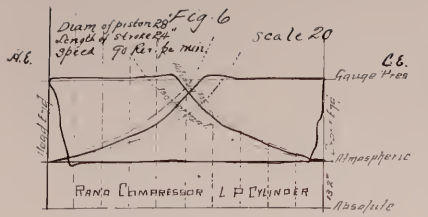


Fig 4
Scale 60.
C.E.
H.E.
Gauge Pres
Atmospheric
Absolute.
Area by Planimeter 2388 sq in
Area by Planimeter 2375 sq in
INGERSOLL COMPRESSOR STEAM END. 24"x30"
SHOWING HYPERBOLIC CURVE


Speed 75 RPM
Fig 5.
Scale 60.
C.E.
H.E.
Area by Planimeter 2175 sq in
Area by Planimeter 2468 sq in
Ingersoll Compressor Steam End


Diam of piston 28"
Length of Stroke 24"
Speed 70 Rev per min.
Fig 6
Scale 20
H.E.
C.E.
Gauge Pres
Atmospheric
Absolute
RAND COMPRESSOR L P CYLINDER

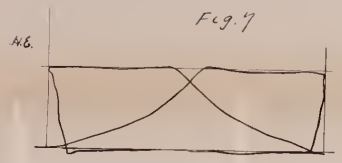
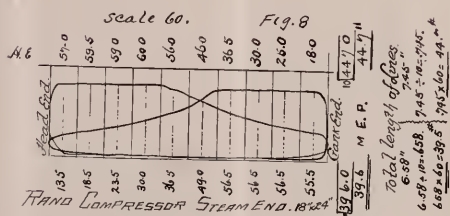


Fig 7
H.E.
C.E
RAND COMPRESSOR. L P CYL


Scale 60.
Fig 8
H.E.
Head End
Crank End
M E P
Total Length of Lines
RAND COMPRESSOR STEAM END. 18"x24"

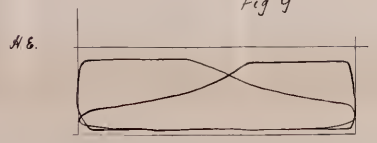
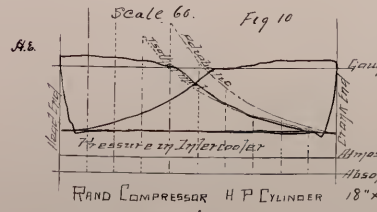
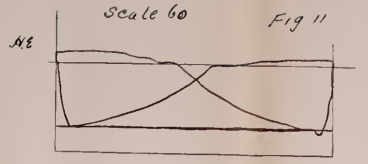
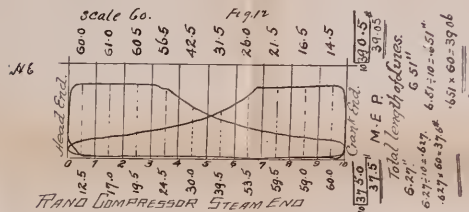
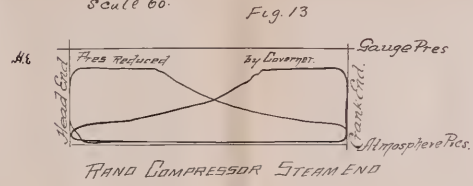


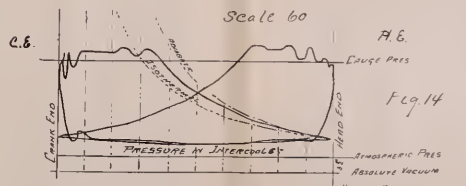
Fig 9
H.E.
C.E.
RAND COMPRESSOR STEAM END

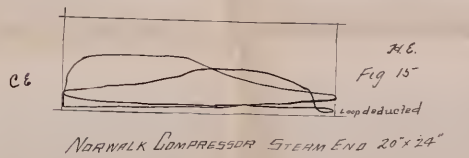

Scale 60.
Fig 10
H.E.
C.E.
Head End
Crank End
Gauge Pres
Pressure in Intercooler
Atmospheric.
Absolute.
RAND COMPRESSOR H P CYLINDER 18"x24"

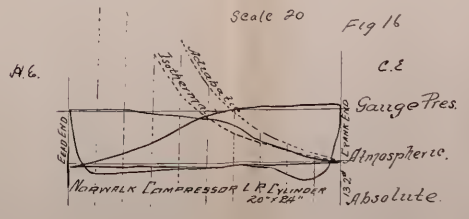

Scale 60
Fig 11
H.E.
C.E
RAND COMPRESSOR H.P CYLINDER


Scale 60.
Fig 12
H.E.
Head End
Crank End
M E P
Total Length of Lines
RAND COMPRESSOR STEAM END


Scale 60.
Fig 13
H.E.
Gauge Pres
Pres Reduced by Governor
Head End
Crank End
Atmosphere Pres.
RAND COMPRESSOR STEAM END


Scale 60
Fig 14
H.E.
C.E.
Gauge Pres
Crank End
Head End
Pressure in Intercooler
Atmospheric Pres
Absolute Vacuum
NORWALK COMPRESSOR H P CYLINDER 18"x 24"


H.E.
Fig 15
C.E
Loop deducted
NORWALK COMPRESSOR STEAM END 20"x 24"


Scale 20
Fig 16
H.E.
C.E
Gauge Pres.
Atmospheric.
Absolute.
NORWALK COMPRESSOR L P CYLINDER 20"x 24"

Returning to the discharge line; it might be well to remark that wavy line may be due to another cause besides the action of the discharge valve, viz.: the pulsations in the discharge pipe line caused by re-starting the flow near the end of each stroke of the piston. This line will be found to vary with different speeds.

The volumetric efficiency is usually stated as a certain per centum of the theoretical piston displacement, i.e., the actual quantity of air delivered into the discharge pipe line is a certain per centum of the theoretical displacement of the piston. This vol. efficiency may be figured from the card. The total length of the card A—G represents the full length of the stroke. The point F indicates the position of the piston when the compressed air in the clearance has expanded down to atmospheric pressure, as indicated by coming in contact with the atmospheric line at this point, pointing to the fact that G—F represents the amount of air, at atmospheric pressure, that was left in the cylinder at the completion of the stroke, not discharged but bottled up in the clearance of the cylinder end.

When the piston starts its stroke from the other end, it has to travel to the point B before the intake air reaches the atmospheric pressure, indicated by touching the atmospheric line. From this it is deduced that we only have the vol. B. G. at atmospheric pressure to compress, and we have B—F delivered. A—G represents the full stroke; B—F the amount delivered; the proportion of B—G to B—F, reduced to percentage, is the volumetric efficiency

The compression line, as shown by an indicator card, should be somewhere between the adiabatic and isothermal lines, which lines can be readily plotted on the card by the use of the following table, remembering the pressures given are absolute and measured from the line of perfect vacuum. The line of perfect vacuum varies for different elevations, being at sea level and 30 deg. mercury, 14.7 lbs. per sq. inch below the atmospheric line. At 27 deg. of mercury, our elevation, it would be 13.23 lbs. per sq. inch—initial pressure.

	10.	20.	30.	40.	50.	60.	70.	80.	90.	
Multiplies for	1.16	1.368	1.652	2.053	2.652	3.633	5.45	9.64	25 57	Adiabatic
any initial pres	1.111	1.25	1.428	1.677	2.00	2.50	3.333	5.00	10.00	Isothermal

In this table, it is remembered that in the curve of constant tempt (isothermal curve) the pressure varies inversely as the volume and in the adiabatic curve the pressure varies inversely as the 1.41 power of the volume. Pressure and volume are taken at unity and the length of the card is divided into ten equal parts. The refinement of the platting of the curves is only a matter of the number of division in the length of the diagram. For ordinary purposes ten divisions give sufficient precision. The isothermal curve in compressors will never run through more than ninety per cent. of the length of the stroke and the table has been calculated accordingly. The length of each diagram in this paper is 3.90 inches. Figs. have been reduced to 2½ inches.

Figs. 2, 3, 4 and 5 were taken from an Ingersol straight line piston inlet single cylinder compressor. Figs. 2 and 3 are both from the air cylinder and each card shows both ends. The piston diam. is 24 inches and length of stroke 30 inches. There is a slight defect in the suction line in that it rises above the atmospheric line, otherwise it shows that this straight line compressor is in pretty good shape and doing good work. Of course, with straight line, single compressor cylinder, the air will always be delivered at a high temperature. This results in a great loss.

Figs. 4 and 5 are steam end cards and are given here in the interest of young members who might like to do some figuring and make a few comparisons. It might be mentioned that it is sometimes difficult to determine from a steam end card the exact point of cut-off. In Fig. 4 it may be noticed that the position of the hyperbolic curve indicates that we have not got the exact point of cut-off, expansion beginning earlier than we show it.

Figs. 6 and 7 are from the low pressure cylinder of a Cross Compound Rand Compressor, and show that the compression curve holds rather closely to the adiabatic curve on both ends,

indicating defective cooling. The head and expansion line is not a good line. The inlet valves of this cylinder are mechanically operated from an eccentric on the fly-wheel shaft.

Figs. 8 and 9 are steam end cards of the same side of the engine as Figs. 6 and 7.

Figs. 10, 11, 12 and 13 are from the high pressure side of the Rand Compressor. The valves in the high pressure cylinder are all poppit valves.

Figs. 14, 15, and 16 are from an old style Norwalk, which has been in use on this colliery for upwards of twenty years. These figures are given to show the combined results of lost motion and badly set valves.

The writer must bespeak the indulgence of the members for the incompleteness of this paper, for the lack of absolute precision in working out the diagrams and for its rather poor general arrangement, pleading the pressure of very diversified duties which prevented any continuous mental application to this subject.

A CANADIAN DELLWIK-FLEISCHER WATER GAS PLANT.

By Ernst A. Sjöstedt, Sault Ste. Marie, Ont.

It should be a matter of some pride and interest to Canadian metallurgists to know that one of the most important improvements of the age in gas making—the Dellwik-Fleischer water gas process—was early adopted by a Canadian firm; but as this plant still remains the only one of its kind in all America, in spite of its great merits and economic adaptability for many and diverse purposes, I gladly take this opportunity of giving it the endorsement which it deserves, with the hope of advancing the general adoption of the same.

In looking through the voluminous literature on water gas of only a few years ago, and making deductions therefrom, we are certain to arrive at the same opinion as expressed by some of the foremost gas engineers in America and of manufacturers of well known gas producers when they describe water gas as "A gas which never can play any very important part in the industrial field, owing to the large loss of energy entailed in its production, although there are places and special purposes where it is desirable, even at a great excess in cost per unit over producer gas." This, I fear, represents fairly well the general opinion of many should-be users of water gas at the present time, but such a view has long since become obsolete, and it is about time for us to wake up to this fact, and to the realization of the great possibilities in store for the Dellwik water gas, and the economy and convenience possessed by water gas when produced by the Dellwik principle.

The Dellwik Water Gas

The difference between the old (Lowe) water gas and the Dellwik gas is not one of chemical composition, nor one of appli-

cation, but rests solely on the simple and economical manner in which it is produced. Water gas making by the old system was an intermittent process in which the gas was made by blowing up the fuel bed of the producer with a light blast of air to a high state of incandescence (and in some cases utilizing the resulting lean producer gas), then shutting off the air and forcing steam through the fire, thereby disassociating the steam into its elements of O and H, the former combining with C of the coal, and the latter being liberated:

$$C+H_2O=CO+2H$$

The result of such a procedure is the consumption of about 75 per cent. of the fuel in the production of the required heat for disassociating the steam, leaving only 27 per cent. of the fuel for water gas generation; ¾ of the time being devoted in the heating-up stage, and only ¼ of the time for water-gas production.

By the Dellwik-Fleischer system this has all been reversed. The water gas generation by this method produces no carbon monoxide during the period of heating, but brings about a complete combustion of the carbon, under the formation of waste gases only (CO_2 and N), and the time of heating up occupies less than 20 per cent., while that of the gas generation is over 80 per cent. of the total. The yield of gas from the fuel is consequently also greatly altered in favor of the Dellwik-Fleischer method: the total yield of the water gas per lb. coke by the old process being only 15 to 20 cubic feet (=30,000 to 40,000 cubic feet per ton coke), whereas by the new system 35 to 45 cubic feet are obtained per pound of coke (or 70,000 to 90,000 cubic feet per ton).

In order to explain how these results (which by the German Patent Office and many eminent investigators at first were pronounced impossible) still are attainable, the following figures are presented: Under the supposition that in one case the C is burnt to CO, and in the other to CO_2 (in each case with the theoretically proper quantity of air), we find that:—

		B.T.U.
By the old process :		
1 mol. C = 12 lbs. burnt with 16 lbs. O to CO develops (12x4450)=		53400
The escaping 28 lbs. CO (at 1300° F.) carry away (28x1300x.248)=	9027	
And the accompanying 52.9 lbs. N. carry away (52.9x 1300x0.244)=	16780	25807
Leaving available heat units in coke bed.....		27593
By the D-F process :		
1 mol C = 12 lbs. burnt with 32 lbs. O to CO_2 develops (12x14544)=		174528
The escaping 44 lbs. CO_2 (at 1800° F.) carry away (44x1800x.217) =	17186	
And the accompanying 105.8 lbs. N. carry away (105.8 x1800x.244) =	46467	63653
Leaving available heat units in coke bed.....		110875

From this we see that after the heating up of the coke bed about four times as much heat remains available for the production of water gas by the Dellwik-Fleischer as by the old process.

Having reached incandescence in this direct and rational way, the fuel is now subjected to the action of the steam, the supply of which is carefully regulated so that the oxidation of CO to CO_2 by steam, which always takes place to a certain extent in the old process, is here avoided, and the result is, as above indicated, that with a fair coke the usual practise is to produce 70,000 cubic feet gas per ton coke by the Dellwik-Fleischer system as against 34,000 cubic feet by the old process.

Compared with producer gas (Siemen's, Dawson's, Mond's & Taylor's), water gas is practically all combustible, while the producer gas generally contains about 60 per cent. (by volume) incombustible constituents, as seen from the following table, showing their general chemical composition:

	Water Gas. Theoretically.	Water Gas. Practic. Av.	Producer Gas. Practic. Av.
Carbon monoxide....	50	40.0	30.0 to 27
Hydrogen.....	50	51 5	3.0 to 18
Marsh gas.....	—	.5	4
Carbon dioxide.....	—	5.0	4.5 to 5
Nitrogen	—	3.0	63.5 to 46
Total combustibles.	100%	92%	33% to 49%
Available heat per cu. ft. gas.....		322 B.T.U.	139-157 B.T.U.

The Lake Superior Power Co. Water Gas Plant

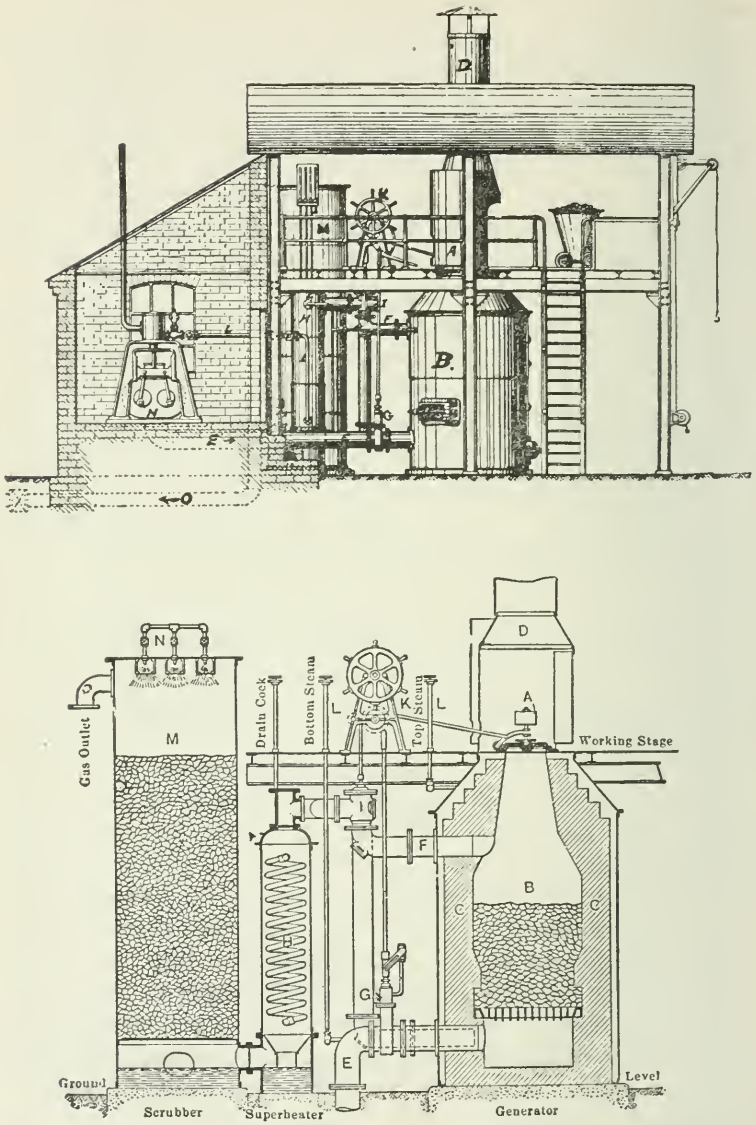
All these facts came to our notice a few years ago, and after having investigated the subject carefully and visited plants in active operation in Germany and Sweden, the Lake Superior Power Company decided to avail themselves of the new invention, and to erect a water gas plant based on this principle, in connection with their process for desulphurizing the pyrrhotite used in the manufacture of SO_2 gas for the production of a bisulphite liquor for their sulphite mill, and for the manufacture of liquid sulphurous anhydride. (x)

This plant consists of two No. IV generators complete with scrubbers, blowing engine, boiler and gas holders, each generator having a capacity of producing about 20,000 cubic feet water gas per hour, and the two operating will, when allowance is made for time lost in cleaning grates, etc., produce a total of 800,000 cubic feet of water gas per 24 hours.

The general construction of the plant is shown by the attached illustrations (reproduced from the *Engineering Magazine*, November, 1903, page 210), and the modus operandi is as follows:—

The coke is charged into the generator at A, until a bed of 3 to 4 feet depth is formed, when to the ignited coke a strong air blast from the blowing engine N is admitted through blast pipe E under the grate, top valve A being open. Under full combustion of the carbon and the formation of CO_2, which escapes through chimney D, an incandescent heat of the coke bed is obtained in less than two minutes, when by means of an ingenious interlocking system of valves, operated by ratchet wheel K, the blast is cut off at G, gas valve I opened, top valve A closed, and steam admitted through L or L_1 (alternately from top and bottom of producer so as to maintain uniform heat and prolong the life of the brick work lining). During eight to ten minutes, or until the test flame shows indication of a weak gas, the steam is thus admitted and the water gas process continued, after which the valve system is reversed, the steam valve shut off, the water

(x) See article, Acid Making from Pyrrhotite, by E. A. Sjöstedt, Jour. Can. Min. Inst., vol. vii , p. 480..



DIAGRAMMATIC REPRESENTATION OF DELLWIK-FLEISCHER WATER-GAS PLANT.

gas valve closed, top valve opened, coke charge admitted, and the blast again turned off for heating-up and preparing the coke bed for another water gas period. The water gas thus produced enters through gas main F, either direct or by way of the intermediate steam superheater H, to scrubber M, where it meets a water spray from sprinklers N, and is thereby cleansed from dust and sulphur vapors. From the scrubbers the now dry and purified gas passes through the gas outlets O to the gas holders, which in our case are two in number, each holding 20,000 cubic feet of gas. From here the weight of the holder forces the gas through a system of pipes, leading to places of consumption.

From first to last our water gas plant has given us great satisfaction, no trouble having been encountered, nor any accident having occurred to detract from its general usefulness. Having improved our roasters so as to make any auxiliary fuel unnecessary, the plant has been used very intermittently; but we have found it economy and a great convenience to operate the same even at times when needing gas only at the rate of a few hundred thousand cubic feet per month, for use in our laboratory and for welding purposes in the machine shop. The simplicity of the plant and the ease with which it can be handled make it a simple matter to start up and shut down at leisure, running the same for a few hours while filling our gas holders, and after the gas has gradually been consumed, again starting the producer and refilling the gas holders, which require only a couple of hours' time and the labor of two men. The cost of the gas, with coke at $6.00 per ton, varies from 15 cents (when running the two producers continuously), to 50 cents per thousand cubic feet (when running the plant intermittently as above referred to). Counting on the production of 70,000 cubic feet of water gas per ton coke, a day's running expenses will be made up of the following items:

Expenditure:	
Coke, 11.5 tons at $6	$69.00
Steam	20.00
Labor, 4 men at $2.50	10.00
Superintendence, power, water, light, depreciation and repairs	21.00
	$120.00
Product:	
800,000 cu. ft. water gas at 15c	$120.00

APPLICATIONS OF THE DELLWIK WATER GAS

From what has already been said, we find that the yield of water gas by the Dellwik invention is more than double that of the old process, and the consumption of coke in the heating-up stage is reduced by one-half. The quantity of fuel required for producing the necessary amount of steam for power and gas-making is from 15 to 20% of that used in the generator, consequently we obtain from the Dellwik water gas the remarkable net yield of 75 to 80% of the heating power of the fuel. For this reason and owing to its high calorific value and high temperature of combustion with air without preheating or regeneration (3,500 to 4,000° F.), the value of this gas for many and various purposes is self-evident. Speaking generally, its advantage consists of a saving in fuel, time, labor, and of an improvement in the quality of the work produced, especially where a high and even temperature is required. For cheapness, quickness and excellence of work it offers particular advantages for welding, brazing, soldering, forging, tempering, annealing and smelting of metals, in the manufacture of open-hearth and crucible steel, pipes, steam boilers, car wheels, in glass blowing, china and pottery firing, in burning lime, cement and plaster, in calcining, drying, heating and evaporation, for fuel and lighting purposes, and for motion power in engines for diverse purposes.

Several of the above applications deserve special mention, and I will now briefly point out the more important ones, using for my authority Inventor Carl Dellwik and Chief Engineer Hugo Dicke, of the Water-gas Syndicate, Frankfort-on-the-Main.

Welding. In the welding of iron plates for boilers the consumption of gas is about 750 cu. ft. (corresponding to about 19 lbs. of coke) per foot welded joint, of which 40 ft. of welded joint of ⅜″ to ½″ iron plate can be finished per shift of 10 hours. In welding gas and water pipes, boiler flues, gas cylinders, poles for electric tramways and arc lamps, the use of water gas will increase the output from 3 to 4 times over that obtained by coke firing, and requires only about one-half the number of laborers. In making car wheels, the welding of one wheel-star ordinarily requires 220 lbs. coal and 132 lbs. coke at a total fuel expense of

about 28c., whereas by water gas 7 wheels per hour are turned out with 8,800 cubic feet of gas, at the cost of fuel of about 15 cents per wheel. In specially constructed furnaces for the purposes of chain welding, the cost of fuel is reduced by at least 40 to 60 per cent., while the clean heat of the gas and the consequent absence of dust and slag from the welding surface result in a better and more reliable weld.

Brazing and Soldering. For this purpose water gas is particularly advantageous owing to its applicable source of heating; consequently it is being used in the manufacture of bicycles and tubes of thin metal, for gas cylinders for railway carriage lighting, self-lighting buoys for compressed gas, etc., also in the manufacture of ornaments and jewelry. On account of its purity it has also proved especially suitable for lead burning, which ordinarily is done with hydrogen gas, the production of which costs about twenty times as much.

Forging and Heating. When objects of similar size and shape are to be made, water gas is particularly well adapted, but even for ordinary forges in machine shops, etc., the Dellwik gas has been applied with great success, having been found to be a great advantage to the blacksmith owing to the iron being exposed to view during the process of heating besides giving a clean fire and a constant supply of heat, easily controlled by the simple turn of a valve. Iron bars 2⅜″ square are welded together with water gas in four minutes, 1⅝″ square in 3 minutes, 1″ x 1¾″ square in 2 minutes, and 1¾″ round in about 1½ minutes. For the purpose of heating rivets, very convenient and effective heating furnaces for water gas have been devised and have proved to offer even greater advantages than the blacksmith forges.

Tempering. The application of water gas for the manufacture of knives, scissors, swords, saws, tools, etc., was made before the Dellwik system of water gas-making was invented. Experience shows that not only is the heat equally distributed but the bars come out all of one even color and temperature; and three times more work is turned out now, at half the price, as compared

with tempering by coal fire. This gas is also used in the manufacture and tempering of watch springs, needles, etc.

Annealing. Special stress is laid on the advantage of water gas in annealing of jackets of ordnance and of plates for the outer-sheeting of torpedoes and in the tempering and annealing of rifle barrels.

Steel Manufacture. The advantage of mixing water gas with producer gas in an open-hearth furnace of ordinary construction has long been appreciated at an English steel works, where the charge is smelted with a mixed gas, after which the water gas is shut off and the process continued with unmixed producer gas until an hour before tapping when water gas is again added, so as to make the steel as hot and liquid as possible. The result of adding 1,800 cubic feet of water gas per ton steel (=90 cubic feet. per cwt.) is an increase in production of about 26%. Used unmixed in open-hearth furnaces water gas should also be highly advantageous as the heating effect of the water gas is about 39% higher than that of the producer gas; and when we further consider that in the production of producer gas about 30% of the heat value of the fuel is consumed and that in making water gas 85% of the actual heat value of the coke is obtained, it is evident that the total heating effect of pure water gas is ($85 \div 70 \times 1.39 =$) 1.68 time as great as that of producer gas. Consequently, there seems to be no doubt of the importance to steel makers in adopting an exclusive Dellwik water gas firing.

Glass-making. For the purpose of glass smelting and glass blowing water gas is used to great advantage in Bohemia and Stockholm, resulting in a considerable reduction in the cost of fuel. At a glow-lamp factory making from 5,000 to 7,000 lamps per day, and where city coal gas was previously used, the introduction of the Dellwik gas reduced the cost of fuel about 80 per cent. in soldering the glass bulbs and in heating the lamp during the vacuum pumping; and for the carbonization of filaments which previously was done by means of petroleum, at a cost of $4.50 per bbl., a corresponding amount of work was afterwards performed for $1.65 expended in water gas, besides making a saving of one man per shift. In smelting enamels in the Perrot

furnace, Dellwik water gas accomplishes an equal amount of work as coal gas at about one-eighth the cost of fuel.

Boiling, Evaporating and Distilling. Comparative tests have shown that under exactly similar conditions 1,000 cubic feet of water gas will evaporate an equal amount of liquor as 450 cubic feet of coal gas, and as the average cost of this gas amounts to about $1.00 per 1,000 cubic feet, the use of the Dellwik water gas reduces the cost to about one-third.

Power. Water gas is eminently adapted for driving gas engines on account of its smokeless combustibles. In small motors where 35 cubic feet of coal gas are required per H.P. hour, 70 cubic feet of water gas suffice, and in a large engine, averaging about 23 cubic feet coal gas per H.P. hour, 45 cubic feet of water gas are required. A gas engine designed for illuminating gas works equally well with water gas, and the cheapness of the Dellwik gas makes this gas the most economical source of power. As compared with the producer gas, the cleanliness and high calorific power of the water gas constitutes important advantages. The following table will show the economical results obtained (in England), using different gases in a 250 H.P. gas engine (with coal gas at 70 cents per 1,000 cubic feet., boiler coal at $3 per ton, gas coal at $3.25 per ton, coke and anthracite at $4.00 a ton, and wages at 8 cents per hour):

	Cost of Fuel.	Total Cost.
Coal gas (23 cu. ft.) per H.P., hour.....	.660c.	1.61c.
Steam (3.3 lbs. coal) per H.P., hour	.426	.57
Dellwik water gas (45 cu. ft.) per H P., hour	.248	.36

Illumination. On account of its high flame temperature water gas lends itself admirably for incandescent gas light and is used for such purposes in industrial establishments as well as in some towns where non-carburetted Dellwik gas is distributed. Incandescent lamps for water gas are of simpler construction than those for coal gas lamps, but should be provided with a stronger mantle, owing to the high temperature of the water gas flame. In those places where no gas works as yet exist it would be advisable to make pure water gas, both owing to the cheapness of the plant (one-half to one-quarter of the cost of a coal gas plant)

and the price of the pure water gas (about one-third that of coal gas). The capacity of existing coal gas works can be largely increased at a comparatively small cost by the erection of an auxiliary water gas plant for the purpose of mixing water gas with coal gas, especially in places where a good market for coke does not exist, as by converting the entire output of coke into water gas the capacity of the combined plant would be four times that of the original coal gas works.

One pound of coal yields 4.65 cubic feet of coal gas and about .65 lbs. of coke. If we, from this, take the coke required for firing retort (about 15%) there still remains .5 lbs. of coke to be converted into (16 cubic feet) water gas. Thus we will receive 20.65 cubic feet mixed gas per pound coal. With such a mixture the Welsback lamp, consuming 7 cubic feet per hour, will produce 100 Heifner (=88 Eng.) candles equal to 14.3 H. candles per cubic feet, or 293 H. candles per pound coal; while the coal gas will consume 3.8 cubic feet per hour and produce 60 H. candles, yielding 72 H. candles per pound coal. Consequently we obtain from the mixed gas about four times as much incandescent light by distilling one-quarter of the coal and converting the resulting coke into water gas. To carburet this mixed gas with oil is also easily accomplished.

In the following table is given the approximate cost (in England) of the different lights used (with retort gas at 55c. per 1,000 cubic feet, water gas at 20c., and carburetted water gas at 56c.):

	Average. Candle Power.	Cost Per Hour.	Cost per 1,000 c.p., Hour.
Petroleum	40	.814c.	20.4c.
Retort gas, ordinary burners	16	.280	17.5
" " Argand "	30	.504	16.4
" " Welsback "	50	.256	5.12
Pure W. gas " "	75	.144	1.92
Carburetted W. gas, ordinary burners	22	.28	12.72
Elec. light, glow lamp burners	16	.4	25.

Heating. Compared with the heating of dwellings by means of coal gas, the Dellwik water gas has the following advantages: (a) The cost of a water gas plant is only one-third that of a coal gas plant of equal capacity; (b) labor wages in operating a water

gas plant is only one-quarter to one-fifth that of a coal gas plant; (c) the relative value of the water gas for heating purposes is to retort gas as .588 is to 1; that is, 1,000 cubic feet water gas corresponds to .588 cubic feet coal gas.

Below is shown the cost (in Germany) of heating with coal gas at 75c. per 1,000 cubic feet, with water gas at 25c. per 1,000 cubic feet, and with coal at $3.75 per ton:

Coal Gas. (550 B.T.U. per cubic ft.): 100 pounds of coal yielding 465 cubic ft. gas, with a useful effect in the stove of 90%, will deliver (465x550x.9=) 255,000 B.T.U. The cost of this gas is (465x.75=) 34.9c.

Water Gas. (275 B.T.U. per cubic ft.): To produce 255,000 B.T.U. from water gas, allowing the useful effects in the stove of 90%, (255,000÷275x.9=) 1,030 cubic ft. would be required, costing (1.030x25=) 25.7c.

Coal. (1,266 B.T.U. per pound): With the usual stove efficiency of 16%, it would require (255,000÷12,600x0.16=) 121 pounds of coal to develop 255,000 B.T.U., or a fuel expense (121x375÷2,000=) 22.2c. Thus we see that the Dellwik water gas for heating purposes is about one-third cheaper than coal gas and only a little dearer than coal, besides possessing the advantages for freedom from soot and smoke, which again would mean a salutary, refreshing air that soon would be appreciated in any community in the event of pure water gas being introduced for heating and cooking purposes.

Conclusion

The general utility of the Dellwik water gas for all purposes of heat and power has now been briefly indicated, and the conclusion we arrive at is that in large industrial establishments the erection of a central Dellwik water gas plant would prove of the greatest general utility and possess many advantages over any other gaseous or solid fuel, not only as regards cleanliness and convenience but in ultimate economy as well.

PROSPECTING IN WESTERN CANADA.*

By D. D. CAIRNS, Queen's University.

British Columbia has been called the "Mineral Province" of the Dominion, and our latest statistics show the term to be correctly applied. When with this province, moreover, we include the Yukon, and thus consider the Pacific slope of Canada, we have an area producing more metallic minerals than all the rest of the Dominion taken together. In 1903 the production of the metallic minerals, gold, silver, copper, lead, iron, nickel and zinc, and also coal and coke, in British Columbia and the Yukon was $29,220,954, as compared with $22,108,120 for the rest of Canada. However, when all the numerous non-metallic minerals and structural materials and clay be taken into account, the balance is slightly against the Pacific slope. Yet Western Canada is distinctly in the lead in respect to the production of metallic minerals, and with the rapidly increasing production of coal and coke, and the attention now being paid to the zinc and iron resources, mining in the west is assuming very important proportions. Prospecting, or the initial stage of mining, is that part of the work upon which all the rest depends. It is therefore the purpose of this paper to attempt, in some measure, to discuss the subject of prospecting, particularly as it applies to that area between the Pacific Ocean and the foothills of the Rocky Mountains.

When one decides to spend a season in the search of minerals, the first question to decide is how to meet the necessary expenses incidental thereto, which are often quite considerable; and the prospector's "grub-stake," as he calls it, is his chief source of anxiety.

A great many men work in the mines all winter, or at some other work, but chiefly at mining, and save a sufficient sum of money to enable them to work their claims and prospect

* Student's paper sent in for prize competition.

during the summer months. These men constitute, probably, the best class of prospectors, because they thoroughly understand mining, and generally work their claims intelligently.

Another class of men are provided with money by others, who, in return, receive a share or interest in all claims staked. Business men and others desiring to acquire mining interests, provided they associate themselves with honest, experienced prospectors, find this method a satisfactory one. There is, however, always the risk of employing unreliable men for work of this character. Again, if the prospector be dishonest, if he find anything really promising, he is quite likely to adopt some means of depriving his employers from sharing his good fortune.

Meanwhile, the outsider who acquires mineral property in this fashion usually pays the annual assessment charges for a number of years on a claim he has never seen, and then either sells his interests to some one else or lets the title lapse. It is commonly the case that a very large proportion of the men who buy claims or pay assessments on those they hold, have never seen their property, but rely solely on the prospector's report. It would be wiser in most cases for such men to invest their money in any other property than mining; for surely there is no reason why mining investments should not be made in a business-like way.

Often companies or corporations hire men to prospect for them, either for wages alone or for wages and an interest in the finds. Prospecting of this kind is the most systematic and satisfactory. Again, large companies employ trained engineers to look for minerals, and also, as a rule, to watch for opportunities to buy likely looking prospects from the prospector at a low figure. This can very often be readily accomplished if the prospector does not know the engineer is representing a company. In that event, the price of the prospect will always be in proportion to the supposed importance of the purchasers. There are a number of companies—Canadian American and European—which employ men in the west in work of this character, thus affording desirable openings for many

young engineers; for good salaries are paid, and often there are special opportunities besides. But the work of prospecting in the west is generally carried on by the typical prospector himself, and it is the exception to find the technically-trained engineer engaged in this work; while in the older provinces, and particularly in Ontario, a great many mining graduates gain their first practical experience in this capacity.

The question of expenses being arranged, there is next to be decided the matter of transport and outfit. In most districts, horses are used; in more rugged country mules are requisitioned, or men pack on their backs. A great amount of work is also done along waterways, rivers, lakes, etc., with boats or canoes. Where horses are employed, each man, as a rule, has a saddle horse and from one to four pack horses; two or three men going together for company. Three is a good number, and will always do better than two in the case of accidents. Still, it is common to see one man going out all alone, leading one pack horse, and walking himself, or even with the pack on his own back, and be gone for weeks at a time.

With horses, provisions can easily be taken to last a considerable time—150 to 200 pounds being an average load for a horse in average country. In this class of work the outfit generally travels slowly until reaching the locality to be examined. Then main camps are made, and most of the outfit left at these "caches," as they are called, the men working in the vicinity making smaller camps, but only occasionally moving the main camp.

A man packing on his own back can conveniently take about two weeks' supplies. A gun, ammunition and fishing tackle are generally carried, as in most districts game and fish are plentiful, and the law allows a prospector to shoot game for his own use at any season. The pack generally consists of a roll of blankets containing the prospector's supplies, which he fastens to his back by straps over the shoulders.

If horses are employed, the regular pack saddle is used, and the provisions and heavy and loose material put into panniers,

which are bags of canvas or rawhide, hung over the sides of the animal. The bedding, tents, tools, etc., are put on top, with, a canvas or waterproof cover on top of this, and then the "diamond hitch" is thrown over all with about a thirty foot rope. It is very difficult for the horse to shed his pack.

The provisions taken will, of course, depend altogether on the number of the party, whether a long or short trip is contemplated, and the character of country to be explored. On long, hard trips, considerable judgment must be exercised in provisioning, and the matter is one of more importance than is generally supposed. Thus, for very long trips, it is recommended that no canned meats be taken, as they are bulky, heavy, and likely to spoil. And the same applies, in some measure, to canned fruits, jams and fresh vegetables.

The following is considered an ample supply of provisions to last a prospector one month under ordinary conditions in British Columbia:—

Flour	25 lbs.
Baking powder	12 oz. tin.
Hams and bacon	25 lbs.
Evaporated fruits	5 lbs.
Condensed milk or evaporated cream, about a dozen small tins.	
Butter	6 lbs
Oatmeal and cornmeal	5 lbs.
Granulated sugar	10 lbs.
Beans	10 lbs.
Rice	3 lbs.
Tea and coffee	3 lbs.
Salt	2 lbs.
Pepper	Small tin.
Baking soda	½ lb.
Jam or marmalade to suit taste	5 lbs.
Vegetables	20 lbs.

Nothing should be taken in paper sacks. Everything not in tins or jars should be in cotton sacks.

Conditions will considerably alter the above list. For instance, if game is abundant in a district the prospector may safely carry a smaller load.

In all prospecting there is considerable loss of provisions due to methods of cooking, moving camp, and also bad weather, as it is difficult to keep everything dry at times.

It is always best to get supplies as near the district to be worked as possible. There are Hudson Bay posts in the most northern parts of British Columbia, and it is generally desirable to do most of one's purchasing at these stores when prospecting in that country.

Candles, matches, soap, etc., must not be forgotten. Cooking utensils need not be extensive—frying pans, kettles that nest into one another and preferably graniteware, coffee or tea pot, knives, forks, plates, cups, spoons, perhaps a reflector for baking bread, or, if prospecting is going to be done in boats, so that there is plenty of room, a camp stove might be taken; but in ordinary prospecting in British Columbia, this is never taken. For bedding—a good Hudson Bay blanket. Other sundries will suggest themselves according to the nature of the trip, such as mosquito net, gold pan, pick, axe, shovel, nails, files, compass, rope, hammer, whetstone, and, if boats are to be used, pitch, oakum, draw knife, brace and bits, chisels, caulking iron, saws; and, if looking for placer ground, hip rubber boots are necessary.

Except in rare cases, where the work is done from boats, or where weight is not much of an object, it is best not to take any extensive testing outfit. However, a blowpipe and a few simple reagents are very useful, and should always be taken by those understanding their use. The following is suggested:—Blowpipe, a bottle or two of the solid acids, soda, borax, phosphor salt, platinum wire, platinum forceps, ordinary forceps, small hammer and anvil, closed tubes and open tubes, litmus paper, grease lamp and magnet.

When the outfit is ready, there are two or three methods of prospecting, each having its own advantage. Some men prefer to work carefully in the older camps, where the value

of the deposits have been proved, and where, if they do find anything, they will be able to quickly realize on their discovery. They carefully look up records at the Recorder's office, ascertaining whether claims of value are likely to expire, but chiefly they look for fractions between valuable claims, and do very close prospecting on vacant ground. As claims are often not surveyed until they have become quite valuable, it often happens that by running a few lines approximately with a hand compass that fractions of value may be secured. Again, valuable leads may be sometimes found on claims that can be purchased easily. And in a great many ways the prospector may do well to remain in these older camps.

But those to whom we owe the most are the men who strike out into newer districts, often where the white man has never been before, and where opportunities are greater. These men despise the class who are afraid to strike away from the trails for fear of getting lost, and speak in none too complimentary terms of the "trail prospectors." They open up new districts, and live whole seasons in the most remote regions, often having to wait years for their reward. These men cut the first trails into their camps, build the first roads and bridges, attract people's attention to the district, and are the pioneers of development and enterprise.

In these unexplored, trackless regions all manner of hardships must be endured. Flies and mosquitoes are frequently very troublesome to both men and horses at times, so much so, that it is almost impossible to work in some districts at certain seasons of the year. Horses have to be kept greased, and smudges built, and men often have to grease their hands and faces, or wear mosquito netting. But one does not always encounter wet weather, snow, mosquitoes, etc., and often quite a long trip seems almost like a picnic. With fair weather, good fishing and hunting, nice open country, good companions, and every one feeling hearty and well from being so much in the open air, in case the party is in a good mineral belt, a pleasanter and more profitable summer could not well be imagined.

Once in the field where work is to commence, the prospector searches in all places where exposures are to be seen, preferably along ridges and creek bottoms, if he is looking for quartz, or in creek bottoms and benches if it be placer. It is somewhat surprising how slight a knowledge some of these men have of minerals or geology, but the majority have been at it for years, and they have rules of their own which are of infinite value. They observe closely, and are generally good mountaineers, and to these qualities, coupled with a great deal of perseverance, they owe their success.

When prospecting a creek for placer, the prospectors carry pick, shovel, and gold-pan, or maybe just a gold-pan and small pick. They follow up the creek, and wash the sand in all likely places, always attempting to get the sand as near the bedrock as possible, and they soon become able to judge quite accurately from the colors in a pan how much the ground is worth, and, knowing local conditions, tell whether ground will pay or not. If gold is coarse, what appears to be only a few small particles to the pan may be from very rich dirt, whereas, if gold is fine, it may take hundreds of colors to make a cent. Snake River, Idaho, is an extreme example of this. It takes 900 to 1,000 colors, and each one is visible.

Prospecting for placer diggings in the frozen regions of the Yukon, to the north, presents many features considerably different from those to the south. Here, of course, horses cannot be used as they are in British Columbia, and men pack on their backs, also ground is frozen, and has to be thawed to work.

When it is decided to prospect a certain creek, some point is selected where the creek turns toward a steep bank. Here some of the ground is panned, and although the surface may be no indication of what may be found on bedrock, as the gold may have been washed down from the hillside drift, still, at a point like this it can be more readily determined if there be gold in the creek or not. If it be decided to prospect the creek further, a point is selected below the "forks," i.e., where a ravine or tributary runs into the creek, and here a hole is sunk

to bedrock. Experience has shown that the richest claims are generally below a forks. If indications warrant further operations, more holes are sunk. Work is continued in this way until the character of that part of the valley is determined. But although the whole valley is crosscut, and no pay dirt found, it does not prove the creek barren, and a single hole at another point might expose rich dirt.

To sink these holes, the ground is thawed by fires, and more energy is expended in maintaining the fires and handling the surplus dirt than in handling the pay. Methods have been introduced, with more or less success, for thawing ground by steam and oil. The best time for working is in winter, when water will not run in and extinguish the fires.

If workings are shallow, the ground is worked by ground-sluicing. A ditch is dug through the claim and dammed at the top, the water running over the ground soon wearing down the frozen dirt to the gravel. The sun thaws the sides of the ditch, and the dirt is carried away by the water, so that a space twenty to forty feet wide is cleared to the gravel, which is then run through sluice boxes and the gold caught by riffles. When the gravel is worked to bedrock, another portion is stripped and worked as before.

If the workings are deep, i.e., over ten feet, the ground is worked by drifting, i.e., holes are sunk to bedrock and drifts are run on bedrock by continually thawing the face of the drift.

Claims on a creek are more desirable than those on the hillsides, as in working the upper ones the ground may be sluiced down to the lower ones. It is often difficult to get water on hillside claims.

Look for any kind of rock known to form the matrix of veins, such as quartz, fluor spar, calc spar, etc., and as quartz is by far the commonest, note all outcrops carefully and particularly where it is honeycombed and stained, showing that minerals have been leached out, and only those portions which are unoxidizable, as gold, are left and are liable to be concentrated on top. Gossan is a good indication of mineral at

depth below the decomposed surface. All likely outcrops should be carefully sampled and tested, even if not very promising-looking, and in case it is good, it can be staked later; but if other men are in the vicinity it is best to stake anything that is suspected of being valuable, as it costs only $2.50 to record and hold for a year, and in this time it can be found what is on the claim and, in case it is of no value, little is lost, and if it is good the discoverer has it.

Valuable properties have often been lost by men not risking the recording fee and some one else finding out the values in the ore and staking first. I know of a number of cases of this kind, one in particular, although not of as much consequence as some of the others, is very characteristic, and is as follows:—Two men were prospecting a few years ago in a portion of the Similkameen country, British Columbia, late in the fall, and were in entirely new country. Just as provisions were getting very low, and they had determined to start back the next day, one of them found an outcrop containing some galena and copper which looked fairly promising. But considerable work was necessary to ascertain the prospective value of the discovery. So, instead of staking the claim, with a view to returning in the spring with tools to work, they left their samples on a log in camp and went back without staking, thinking that no one would visit the locality in the meantime. However, it so happened that neither of the partners could return as early as had been proposed, and the property, which proved to be valuable, was located by another party in the interim. In fact, the richness of this ore resulted in a rush to the section, and all the vacant ground for a considerable area in the vicinity was staked before the original discoverers returned. Within a year from the time of discovery the claim sold for $30,000.

Often loose float carrying valuable mineral is found. If the rock has not come far, it is the work of the prospector to trace it to its source, no matter whether found on hillsides, creek bottoms, or elsewhere. If the float is square-cornered and fresh-looking, and other similar pieces are found near, it

is often not a difficult task to locate its origin by following up hill until the outcrop is seen, or until no more float is to be seen. Then by examining the nature of the ground, even when the outcrop is covered, a little digging and good judgment often reveals an ore-body.

If other valuable claims have been located in the vicinity, it is always wise to examine them to see their appearance on the surface, capping, if there is one, the formation in which the ore occurs, the direction in which the leads run, the possibility of extensions, etc., and the general characteristics of the mineral belt. Altogether, it is very desirable to be thoroughly acquainted with the ores of the camp or locality in which you are working, because the minerals which carry the values in one place may not in another, and vice versa. Arsenopyrite, on Twenty Mile Creek, in the Similkameen, carries very high values, and in the camps just to the south it carries little or no values.

In any event, a man should not be deceived by the weathering of the rocks. All uncertain materials should be broken and examined. It is advisable to note and follow contacts, especially if these are mineralized. Localities in which there has been considerable alteration and disturbance, and in which a variety of formations are met are favorable, particularly if these are the older rocks. And in all prospecting a knowledge of geology, particularly in its relation to ore deposits, is very helpful and is essential to systematic work.

It is a help sometimes to remember that in each camp the main veins are generally parallel. Also a true mineral vein, where it exists, is not likely to be isolated, but rather represents in a poorer or richer degree many more within reach, constituting a mineral belt.

One has always to go to a new district with an open mind, and be prepared to find the conditions prevailing different in many features to those to which he has been accustomed elsewhere. Men having the widest experience will most readily adapt themselves to these new conditions, and be in a position to appreciate and investigate the different mineral deposits.

It is well always to get all maps and reports available in going into a new locality, as these may prove of infinite value.

Prospecting for coal differs materially from quartz prospecting. There are places where small detached areas are of value, but these are the exception. It is, to-day, a question, not so much of finding coal measures, as of finding seams that are sufficiently regular, clean and accessible, to be profitably worked. Knowing that seams of coal are stratified deposits, or have been formed during the same geological period as the rocks in which they occur, it will be certain that the coal seams themselves have been subjected to the same movements as the rocks, and having once settled the position of a coal seam in a section, any further observations of dip and strike may just as readily be taken in the rocks which outcrop at the surface as in the coal seam itself, thus facilitating coal prospecting considerably.

Measures are often very regular, and outcrops extend enormous distances. I know of one case in the West where measures can be traced about a hundred miles or more, and practically identical strata are underlying the coal throughout the whole distance. So that in working in this district, it is the particular strata that are looked for, and, as these weather very prominently, and are easily found, the coal is then located under them. But as the measures are folded in immense folds, the coal is only of value where these dip under some river valley having a sufficiently even and easy grade up which to build a railroad.

In British Columbia when a discovery is made the finder stakes and records it. An assessment of $100 in work or money has to be paid on a quartz claim each year to hold the ground. The prospector does his own assessments, as a rule, and in some cases has so many claims that he spends most of his time in maintaining his titles.

The honest prospector, when he thinks he has a "good thing," devotes his whole attention to developing it; but sometimes these men have no idea of proportion, and often have the wildest ideas of the values of their claims. In fact,

it is almost pitiful, at times, to see a man working for years to develop something of no value at all. Maybe it is only a dike he is working, with desseminated iron, carrying little or no values, or a barren quartz vein; but then, whatever it is, perhaps for years he works away uplifted by hope and faith. How much wiser these men would be if they were to have their work more frequently sampled and assayed! But the price of assaying is an object, and it is hard for some to realize that a dollar spent in assaying is just as good or better than spent in development.

But the prospecting is not by any means over when the claims are staked. The ground should all be very carefully examined, and, in British Columbia, where quartz claims are 1,500 feet square, this is a considerable area, especially in a rough district. Then when most likely-looking points have been selected, surface stripping commences, and it is determined whether ore found is in place or not. If not, attempts are made to locate its origin. Next, it is advisable to continue the surface work sufficiently to see how wide the ore is, what is the nature and form of the deposit, the nature of the walls, the direction the ore runs, etc. The sink or drive in best-looking places to get into good solid formation. Assays are made from carefully selected samples, and a very fair idea of the claim may be soon obtained. It may then be thought advisable to sink or tunnel a short distance, 50 or 100 feet, always running tunnels instead of shafts where there is a good tunnel site and where the tunnel can be run in ore. For, above all things, at this stage of the development the main point to remember is to follow the ore. It is well, too, to open one's claim thoroughly on the surface before much underground work is commenced. The old prospector's idea that ore will increase in value with depth may account for a considerable number of the valueless shafts and tunnels to be met with in new mining districts.

Most of the prospecting that has been done in the West has been only for gold, silver, lead, copper, and coal, and

relatively but a small area of the country has been prospected to any extent for these.

In addition to the valuable products above-mentioned, platinum, long known to occur in the Similkameen placers, has been found in the gold-bearing quartz veins of the Burnt Basin, in the Boundary Creek country, and the basic igneous rocks in which it is so often found are known to be as far north as the Atlin district. These rocks sometimes carry nickel and chrome. Cinnabar has been found in many places to the south of Kamloops Lake as well as in the main quicksilver-bearing zone. The oilfields of southeast Kootenay, covering a large area of country, is attracting much attention, and large iron deposits are being discovered on the coast which are likely to prove of considerable importance.

But in prospecting, in all its phases, and in whatever part of the West it be, the most striking feature of all, and the one always seen and generally about the same, is the typical prospector himself—always hopeful, always making new strikes and hearing of new rich diggings somewhere else—he is generally ready to join any stampede to almost anywhere, provided he has the means. Always has a claim to sell, is good-hearted and free, when he has any money. As to the man himself, he is the best of company, and intellectually, far above the average artisan. Very few realize the immense amount of exploration that is done in a new mineral country by prospectors; but how much more would be done if they were better trained. In Ontario, the government has summer schools for work of this character, and these are a great help, but the West has not yet followed the example of our older province.

Accompanied by very many hardships and dangers though the life of a prospector may be, there seems to be a fascination about the work hard to describe. It may be the freedom one feels away from all restraints, the free and easy way of living, the always present hope of fortune, and the constant excitement. It is true, none the less, that once a man takes seriously to prospecting he will follow no other trade.

The young engineer is apt to laugh at the prospector and his views, but this is a grave mistake. The latter may not have any very clearcut conceptions, for instance, of what is meant by a "qua qua versal," or a "synclinorum," but he will probably be able to tell the engineer the best way into and through the country he is going to work. He can often be of great service, and is frequently in a position to render the most valuable assistance. Prospectors observe closely, and although they may not draw the most scientific conclusions from their observations, they may not infrequently teach even the technically-trained man some valuable lessons.

DISCUSSION.

The President—I am sure we have all listened with pleasure to the very interesting paper presented to us by Mr. Cairns. It is a very important matter, the matter of prospecting, as all mining men and mining engineers know, and I am very glad indeed that such a good paper on this subject, which is not often presented, is before us to-day. A great many good counsels are given to the prospectors in it. I have noticed some very good points; of course, some of them I missed. That is a very good advice, for instance, for prospectors not to hold too many claims, as that is certainly the way a great many men waste their energies, by not doing enough on one or two of their most promising claims; they should do the work on those and let the others go. The next point I noticed is where Mr. Cairns speaks of mining not being uncertain provided thorough prospecting is first gone through. That is quite right; the uncertain part is taking up the first thing that comes along and spending thousands on it. But by good prospecting, and by prospecting a great deal and spending the money on the best prospects, the uncertainties of mining are much reduced. Our governments, on that account, should leave the mining lands free to bona fide mining men and not lock them up by disposing of them cheaply and

without any condition making for forfeiture in case of non-working. Other good points made by Mr. Cairns are:—More assays and more sampling should be done. Stick to the ore. A good knowledge of mining laws is required by prospectors. All these are very well taken, indeed. The prospector is a very good fellow, although he sometimes has very exaggerated ideas. Not only the prospector but sometimes the capitalist has that failing. Certainly the prospectors are of very great service to us mining men and to the mining industry. Our governments should do a great deal more for them; they do not do enough, and it is for us to see that they do more in the future than they have done in the past. When I went to the Yukon, about five years ago, there was not trail cut. The prospector had to cut his own trail and to carry his pack on his back. On my return, I agitated that question, and with the help of the Institute was, the very next winter, the means of bringing that question before our Federal Government, who recognized the necessity for it, and they started building roads the next spring. It was thus owing to our efforts that roads were started and built in the Yukon. These roads are now cited as models for Alaska by the geologists and engineers of the United States Geological Survey. The Government should also, and it is done in some of our provinces, give free mining claims to the prospectors for new discoveries, and should even, I claim, extend patent rights to them for claims that they have found and cannot work for the want of the necessary funds. If our governments thus extended patent rights to the poor prospectors in cases where they are unable to work their discovery claims, they would benefit the country greatly, as this generous policy would stimulate exploration.

MINE SURVEYING AS CARRIED ON AT CENTRE STAR MINE, ROSSLAND, B.C.*

By L. Heber Cole, McGill University, Montreal.

INTRODUCTION.

The methods as described in this paper are those employed by the Engineering Staff of the War Eagle and Centre Star Mining Companies, as observed by the writer who was a member of the stuff during the summer of 1904.

The manifest difficulties in the way of using the actual mine surveys for illustrating the paper, have led the author to assume an imaginary mine having but a general resemblance to the Centre Star. All of the maps in the present paper and the detailed references in the text refer to this imaginary mine, which may be briefly described as follows:—

Ore body consisting of two intersecting veins A. and B.

A. striking N. 80°E. dip 67° to N.

B. " N. 80°W. " 67° " N.

Both veins are cut by a reversed fault which strikes N. 25°E.—dip 90°—throw 25 ft. to North.

The mine is assumed to have been sunk to the 5th level, with stopes on 1st, 2nd and 3rd. The shaft is located in the centre of outcrop of vein No. 1 and dips 65° bearing N. 10° W. This comprises a very simple mine but serves as a means of illustrating the methods employed.

I.—SURFACE WORK.

Since the surveying work carried on in connection with the mine is principally underground, the methods used in surface surveys will only be lightly dealt with.

For location work, a transit, with stadia cross-hairs is used. By this stadia method all buildings, etc., are located for plotting on the surface map. When a point is required to be

* Student's paper sent in for prize competition (awarded first prize).

located with any degree of accuracy, or when it is only a short distance from a station, as at the mouth of a tunnel, the work is carried on with a transit taking both horizontal and vertical angles and by measuring the distance on the slope with a steel tape.

As the prospecting was commenced by a tunnel, the surface workings were easily connected with the underground surveys. These were checked by sights down the shaft, which is at an angle of 70°.

The levelling is done with an ordinary Y level with a target rod or else a telescoping rod reading to $\frac{1}{100}$ths of a foot. The line is generally levelled back to insure accuracy. All level notes are reduced to sea level.

571 drift. West

Date 1905.	ADVANCE: Since last measurement: Cont.	ADVANCE: Since last measurement: D.P.	ADVANCE: Since 1st of Month: Cont.	ADVANCE: Since 1st of Month: D.P.	ADVANCE: For 10 day period: Cont.	ADVANCE: For 10 day period: D.P.	Total since commencement	Date given to payroll	MEASURED FROM.					
									feet		feet		on	by.
Jan 10	0.00		0.00		0.00		0.00		0.00	0 78			1/11	Brown
" 13	12.00		12.00				12.00	1/14	12.00	"			1/14	"
" 20	22.00		34.00		34.00		34.00		34.00	"			1/21	Smith
" 30	40.00		74.00		40.00		74.00	1/31	74.00	"	600	079	1/31	Brown

Notes are kept in a standard x-section book Size 7" x 5" (x-sect 10 x 10 to inch)
Cont = men working on Contract D.P. = men working on Day's Pay.
Note book ruled to above form as required.

FORM I.
Measurement of Advance

Accurate bench marks were established at the mine by running a line of levels from the mine to the bench mark on corner of Bank of Montreal, in Rossland, which has been accurately located above sea level by the Canadian Pacific Railway.

II.—UNDERGROUND WORK.

The transit used in ordinary work has a horizontal and a vertical cross hair and complete vertical circle. (Two transits are used, both Buff and Berger,—one with and one with-

out stadia. The one without stadia is preferable as there is no chance then of getting mixed on centre wire.) The compass needle is attached but is never used except as a rough approximate check. The transit telescope is never plunged. The rod used for contour work is five feet long and is brass shod at each end and graduated at every foot. The tapes are 50 and 100 feet tapes of steel ribbon, graduated to feet and 10ths of feet.

All bearings are worked out from the azimuth of the back sight, thus doing away with the use of the needle. Sights are taken on plumb-bob lines or on nails, and the transit read to minutes. Each angle is doubled so as to check reading.

The stations are placed in back of drifts or in caps of square sets of timbers. When placed in backs, a hole about one inch in diameter is drilled at the spot where the station is required and a wooden plug is driven in flush with the back. This plug is from two to three in. in length. Into this is driven a horse-shoe nail with a tag on which is stamped the number of the station. The horse-shoe nail head is pierced so that a wire can be passed through it. A copper wire is then hung so that it can be conveniently reached from the floor of the drift.

To illuminate the plumb-bob string, a piece of tracing cloth, about four by three inches, mounted on a wire frame is held between candle flame and string. To illuminate the cross-hairs in the telescope, a candle is held a few inches in front of object glass and a little to one side. The plumb-bobs used are ordinary brass plummets with long tapering ends. No plumb-bobs with lamps are employed.

The transit tripod has telescope legs and is firmly built to withstand underground use.

When moving from one level to another the transit telescope is covered with a canvas bag.

A button is put on each plumb-bob string, which will slide up and down, and which can be set at any height required.

Measurements of Advance.—The progress made in drifts, winzes and raises is measured on the 1st, 11th and 21st of each month. This is done roughly with the steel band tape. The

(FORM II.)

Advance in _____ Mine.

For _____ Ending _____ 190__

PLACE	FROM	TOTAL SINCE COMMENCEMENT	ADVANCE	REMARKS

_____ Surveyor

Assumed:-

Two veins and one fault -

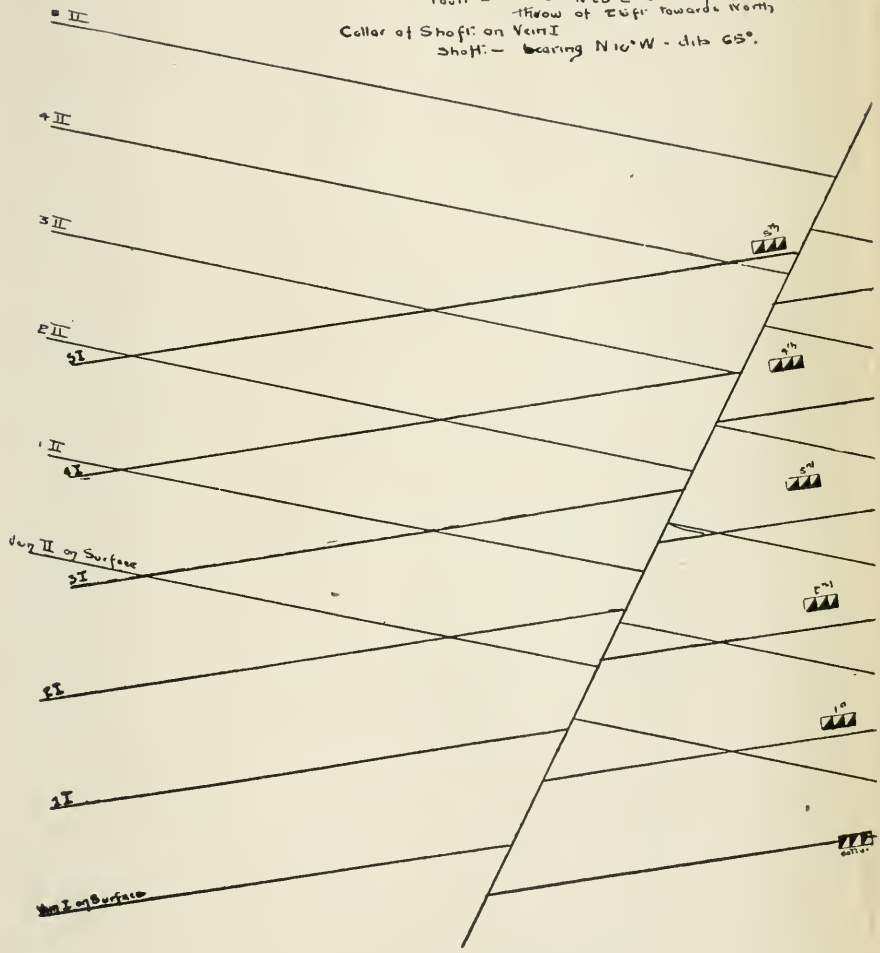
Vein I :- strike N80°E - dip 62° towards North

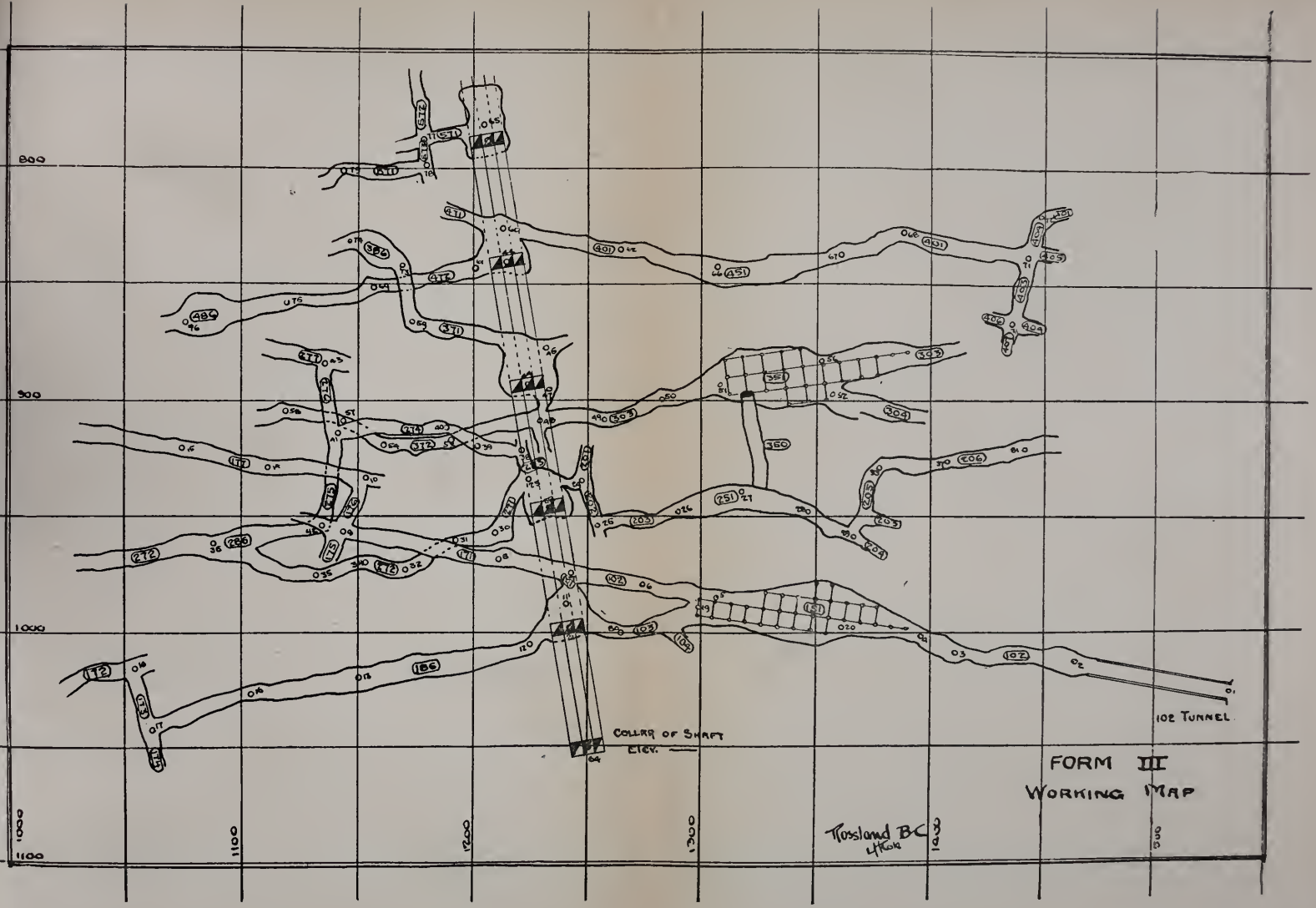
Vein II :- " N80°W - dip 62° " "

Fault :- " N26°E - " perp: with a horizon throw of 150ft towards North

Collar of Shaft on Vein I

Shaft :- bearing N10°W - dip 65°.




800
900
1000
1100
1200
1300
1400
COLLAR OF SHAFT
ELEV.
102 TUNNEL
FORM III
WORKING MAP
Trossland BC
1938

Assumed:-

Two veins and one fault -

Vein I :- strike N80°E - dip 67° towards North

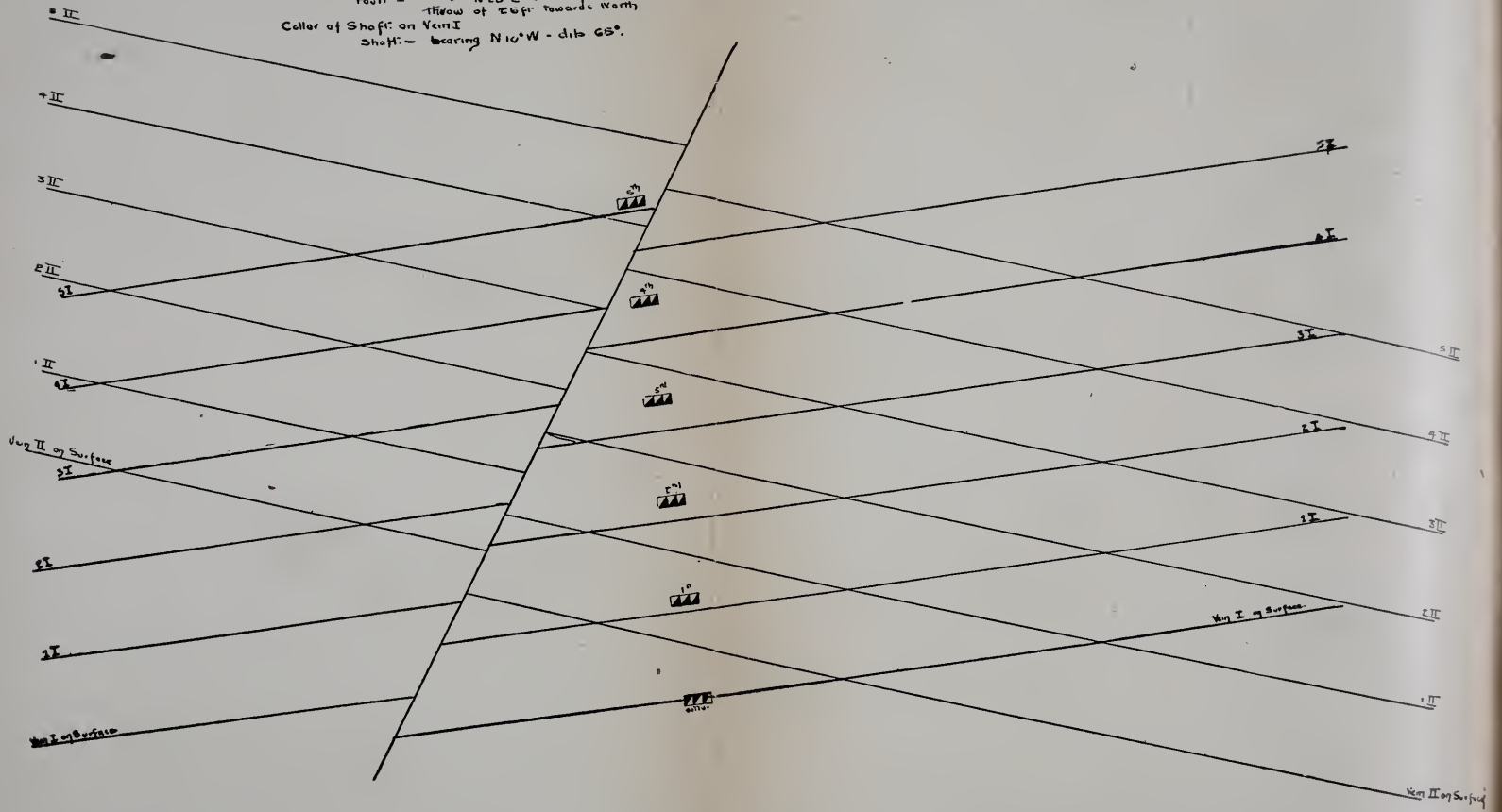
Vein II :- " N80°W - dip 67° " "

Fault :- " N26°E - " Perp: with a horizontal throw of 25ft towards North

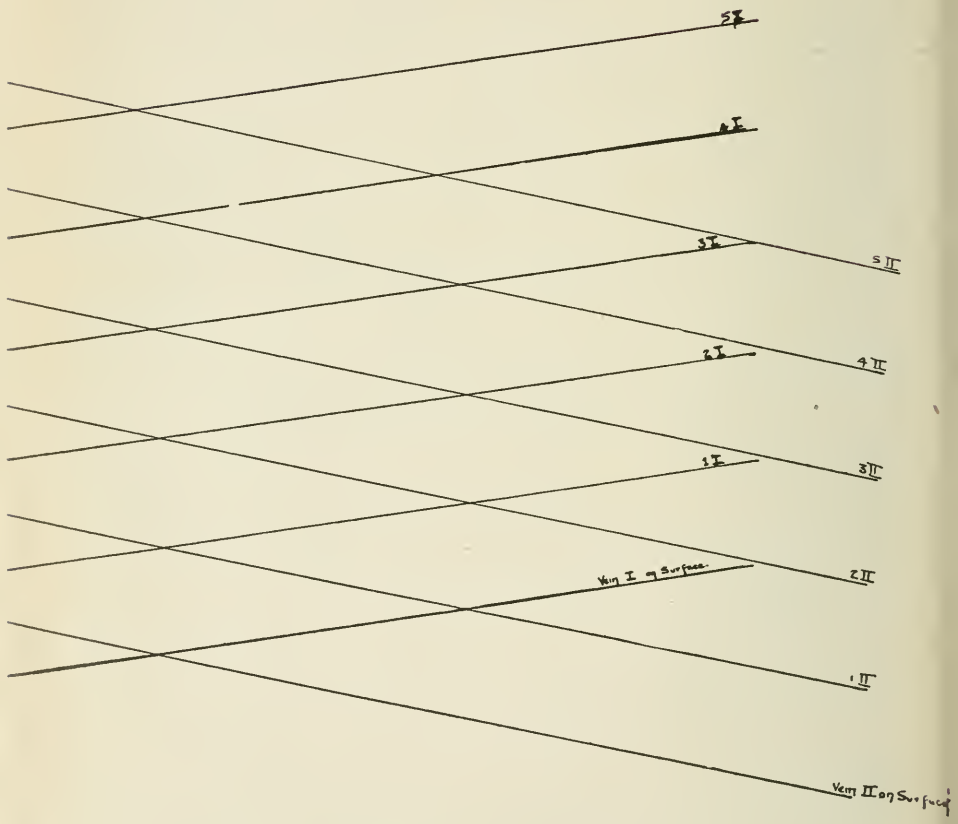
Collar of Shaft on Vein I

Shaft :- bearing N10°W - dip 65°.

This sheet when placed Working Map will show the horizontal plan of veins at each level



This sheet when placed
Working Map will show the horizontal
plan of veins at each level



distance is measured parallel to sides of drift. Measurements are generally taken from some station if possible, or else some mark located on a previous measurement. This measurement is taken in connection with the calculation of the pay given to men when working on contract. Form I shows the method of noting these measurements. Reports are made out each month and handed into the general office. (See Form II.)

Survey of Advance.—The advance made in the mine is the progress made in the drifts, cross-cuts, etc. The advance is surveyed accurately for plotting on the 1st and 15th of each month. It is carried out as follows. (See Form III, working map, 4th level west of shaft.) The transit, tape, plumb-bobs and rod are used. The instrument is set up under station °75.

Station °76 having been put in and plumb-bob hung, the horizontal plate of transit is placed to read 0° and clamped to vernier. A back sight is then taken on the plumb-bob string on Station °69. The vertical axis is then clamped to plate and vernier let loose. A fore sight on Station °76 is taken and vernier clamped and read. The vertical axis is then loosened and the operation is repeated, thus doubling the former reading, if work is correct. If these do not agree, the angle is read a third time. The vertical vernier is set to read 0°, thus making telescope line horizontal. The button on plumb-bob string is set in this horizontal line. The horizontal distance between the centre of the telescope and button is then measured and checked two or three times. The height of instrument above or below Station °75 is measured, as is also the height of the button below Station °76. This gives a means of obtaining the elevation of Station °76. If button cannot conveniently be set on the horizontal line, it is set in plain view from telescope and the angle of inclination is measured and the distance on a slope is determined. Height of instrument and height of button are taken as before and from these the H.D. and V.D. are calculated. The sides or contours between Stations °75 and °76 are next determined. The telescope is still sighted on Station °76 and the rodman holding 0 inch end of tape and rod advances to instrument. Where irregularities in drift occur,

he has his candle lined in by transit and he gives distances to L. and R. to the nearest ½ foot. At the same time, distance from instrument is read from tape by instrument man. The L. and R. given are always the L. and R. of instrument man.

The instrument is then set up under Station °76 and B. S. taken on Station °75, similar to preceding work. The F. S. is taken on candle flame held in centre of drift. The angle is not doubled since sight is not on the station. The height of instrument is not measured. If, as in this case, the drift widens out, extra sights are taken on the sides of the drift and distances measured to locate contours and H. angles are read. When work is required to be surveyed up to date, and a station in the proper place would be blown out by next blast, a sub-station or temporary nail is placed in ties or in board and this is used to survey to face. These are not numbered. For method of keeping the Notes, see Form IV.

486 Drift. Jany — 1/05 Surveyed by — o —

Station	HI	Angle	Bearing	Vert Ang	Slope	Vert Dist.	HP	Hor. Dist.	REMARKS		
75	7.5	178° 00'	S 78° 00 W				3.41	109.5	To station °76 Plug in back 486 drift		
BS 69		356° 00'								L —	R
								60 0		5.0	4.0
								45.5		60	3.5
								20.2		4.0	3.0
76	7.5	179° 00'	S 77° 00 W					20 3	To face 486 Drift	3.0	3.0
BS 75								7.2		3.0	4.6
		27° 00'	S 75° 00 E					30.0	To points around		
		45° 00'	S 57° 00 E					27 7	do		
		90° 00'	S 7° 00 E					9.2	do		
		300° 00'	N 18° 00 E					22.7	do		
		330° 00'	N 48° 00 E					29.5	do	FORM IV	

Setting Directions for Drifting, etc.—When the direction of a drift is required to be changed or a direction is needed for a diamond drill hole, a course is laid out by the survey department for miners to work from. This course generally consists of a couple of plugs in back of the drift from which strings

can be hung to obtain line. The plugs are located by the transit. The plug nearest the station is located like a sub-station and the other plug is placed in line when telescope is set with the bearing required.

The Notes (calculations and bearings for the above sights) are worked out beforehand.

D.D. Hole. 101 Drift — Jany – 1/05. — Surveyed by —

Station	HI	Angle	Bearing	Vert Ang	Slope	Vert Dist	HP	Hor Dist	REMARKS
3. BS. 4.	5.5	135°00 210°00	S85°00'E	4°25'	114.7				To sub-station on end of drill rod
Sub. BS. 3.	4.5	75°00'	N10°00W	10°27'	18.3				To collar of hole
				(Bearing of hole)					

FORM V

Location of Bearing of Diamond Drill Holes.—The bearing and inclination (if any) of the diamond drill holes are determined accurately by means of the transit. When the drill is in position, and the rods are in the hole, these have a direction the same as the hole. They are extended as far as possible back into the drift. A sub-station, or mark on the free end of the rods, is located from the nearest convenient station. For illustration take location of D.D. No. 1, 1st level East No. 102 drift. The sub-station on the rod is located from Station 3 since Station 2 is too close. The instrument is then set up over the mark on the rod and sight taken to centre of collar of hole. The bearing of this sight is the bearing of the hole. When the inclination is required, the vertical angle of inclination to collar is read as is also the height of instrument above sub-station. The holes are generally horizontal. When sur-

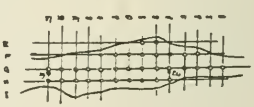
veyed, when drill is not in position, a long rod is placed in hole. Notes for this hole are to be seen on Form V.

Location of Square Sets.—The survey of square set in the stopes is carried out in the following manner. Form III. (Working Map) 1st Level East, Stope No. 151.

Transit is set up at Station 5. Back sight taken from Station °6 and Station °19 is located in ordinary way. Station °19 is placed in centre of a cap of one of the square sets at a measured distance from post on hanging wall side of it. This measurement is made from centre of post. Station °20 is then placed similarly in cap of square set as many sets away as possible. Transit is then moved to Station °19 and Station °20 is located. The bearing thus obtained of line from Station °19 to Station °20 is the bearing of the square sets in that scope. A rough sketch is taken of the square sets and the distances to walls taken so that contours may be obtained. The form of notes and method of keeping them is given, in Form VI.

151. Stope (Location of sq sets) Jany –/05. Surveyed by — + —

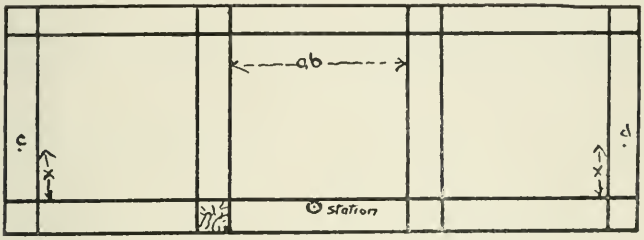
Station	Ht.	Angle	Bearing	Vert. Ang.	Slope	Vert. Dist.	Hor. Dist.	Hor. Dist.	REMARKS.
5 BS. 6	4m	320° 00' 280° 00'	S 50° 00' W				175	973	To station 19 nail in cap 2' to footwall from centre of post Q 37
19 BS. 5	2sp	30° 00' 60° 00'	S 70° 00' E	(Bearing of Sq sets)			2.91	620	To station °20 nail in cap 2' to footwall from centre of post Q 46



FORM VI

Survey of Stopes.—When stopes are of a width of 15 feet and over square set timbers are used; the stope is then surveyed as described under Section 2 of square sets.

Survey of Narrow Stopes.—The contours of these are located in the manner of a drift or cross-cut. A longer contour rod is used. For the long section map, the highest point in the back is located.



Shaft Surveys.—A station is fixed in footwall plate on centre line of compartment, centre compartment if there are three. (Centre is obtained by halving ab.)

Instrument is set up at this station and the dip and direction set off on it. Every fifth set of timbers is set by the instrument.

The set to be checked is measured as follows:—

Distance a. b. is measured on hanging wall plate and footwall plate. These distances are halved and centre points marked by small nails. A line is stretched between these two nails and this line will correspond with the vertical hair of the telescope if the set is in the correct position. This checks the side displacement. Then the distance of the instrument (axis of telescope) from the footwall plate is measured on the outside posts as in sketch and nails put in at c and d. A line is stretched between c and d and line will correspond to centre horizontal hair of instrument if set is correct. This checks running into the hanging wall or footwall. Intermediate sets are checked by the rodman holding a rod upside down against footwall plate and this should read distance "x." And again, when held against side posts of centre compartment the reading with the vertical hair should be ½ ab.

III.—OFFICE WORK.

The notes taken on surface or underground are computed as soon as possible. Only for stations are the N. and E. coords worked out by traverse tables. All other points are plotted by their distance and bearing. (See Form VII.)

486 drift. —— Mine. Note Book 11.-TZT. 1/16/05.

B.B. Set up	Azimuth	Bearing	H D	D E	Calculations E	Calculations N	⊙	Co-ordinates N	Co-ordinates E	Elevation
					97.8	20.8				
69	260° 00'				8803	1.871				
75	178° 00'				.489	104	75.	984.00	1139.00	720 00
	438° 00'			+3.41	109.092	22.775		- 22.78	107.09	66
	180°			-2.75			76	961 22	1031 91	720 66
	258° 00'	S 78° 00' W	109.6	+0.66						

This is worked in pencil and is repealed on a second page as check. Only stations co-ords. are worked out For other points the bearings only are calculated. LR Gurden's Traverse Tables are used.

FORM VII

Note Books.—Stope books are kept which are worked up twice a month. (See Form VIII. for illustrations.) A page is devoted to each floor. These books are ruled so that the spaces represent the distance between the square set posts in the mine to the same scale that the working map is plotted to. All work is done first in pencil and it is not put in ink till the floor is completed. Each square set is given a number and a letter. The letter tells in which row it is at right angles to vein and the number what line parallel to vein.

Ledger.—When there is no doubt that a working place will be permanent, all the notes for that place are copied under their proper level in a ledger. A sample leaf is here shown (Form IX.) This book is indexed so that all notes that have ever been taken for a certain place may be referred to together. If any doubt remains the original notes themselves may be looked up very quickly from their reference number. A loose leaf ledger is kept while there is work still being done

(Fo

B. S.	Station	Hor. Angle	Azimuth	Bearing	H. Dist.	Difference of Elevation

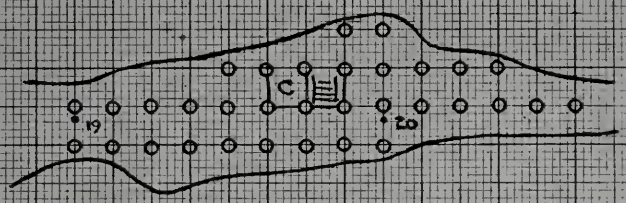
151 Stope Sill Floor. Elev. = —— Jany-1905

35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

HANGING WALL

D E F G H I J

WEST.



EAST.

D E F G H I J

FOOTWALL

35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

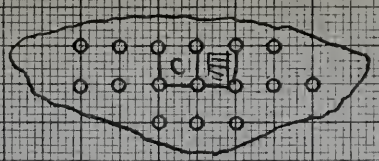
151 Stope 5th Floor Elev. —— Jany-1905.

35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

HANGING WALL.

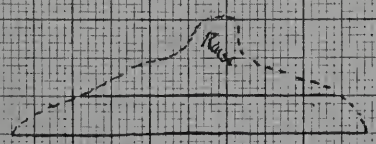
H I J K L M

WEST.



EAST.

H I J K L M.



FOOT WALL.

35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

A separate page is devoted to each floor Plotted in note book x-sectioned to same scale as working map is drawn to

(FORM IX.)

B. S.	STATION	HOR. ANGLE	AZIMUTH	BEARING	H. DIST.	DIFFERENCE OF ELEVATION	COORDINATES		ELEVATION	H. G. BELOW STATION	REMARKS	REF.
							NORTH	EAST				

)RM IX.)

COORDINATES		ELEVATION	H. G. BELOW STATION	REMARKS	REF.
NORTH	EAST				

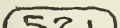
in a drift, and by this means changes may be made comparatively easily.

Collar 3 compartment shaft.

Level station 3 compartment shaft.

Single compartment shaft.

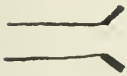
Square set timbering.



Number of working.

Station or survey.

Ore chute.


Mouth of tunnel.

Timbering on long section map.

Station Indexes.—An index is kept of all survey stations located in the mine and on the surface in connection with it. This index gives the place and date of location N. and E. coords, the elevation, the reference to note book in which notes of location are to be found and what kind of station it is; whether it is a plug in back or cap of square set, etc. If a ques-

tion arises about any station it is looked up in this index and all particulars are at hand.

Conventions.—The usual appliances and instruments of a draughting-room are used. The protractor is one with a vernier reading to minutes made by Gurley.

Several 6 foot steel straight edges are employed. Ruling pens made by Alneder are used. Higgins' Inks and Winsor & Newton water colours are made use of. The conventions used on all the maps are as follows:—

Surface Map.—A map is kept of surface work and on it are plotted all the surface stations and boundaries of the claim. The lines of contour are plotted from the detailed levels taken of the claim. All mine buildings and roads and all tracks of C. P. R. are shown on this map as are also the mouths of the tunnels. This map is plotted on scale smaller than that of the underground workings. Ordinary conventional colours are used for the buildings, etc.

The Working Map.—(Form III.) This is the most important map in the whole mine. On it are plotted all the underground workings in plan.

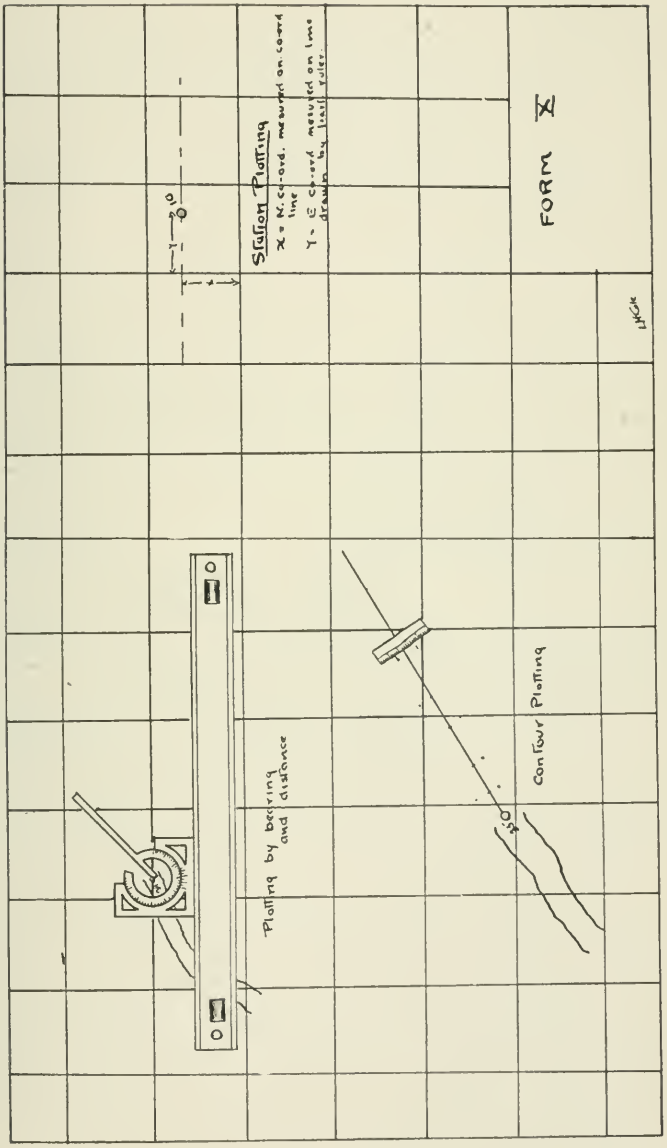
This plan is drawn to a conveniently large scale. Each level is coloured a different colour so as to be readily distinguished. Every survey station is plotted and all the working places are numbered to facilitate reference. The sill floors of square set stopes are plotted. Only horizontal workings are represented, except raises. The plotting is carried on with a parallel ruler and the protractor before mentioned.

The map is ruled into 100 inch squares, with sides N. and S., and E. and W. All plottings are made from these lines. These co-ord lines are numbered; the intersection of the two lines o — o being taken off the claim to S. W. so that no difficulty will arise by the co-ords of a point being negative. These numbers increase to the North and to the East.

The notes are plotted as in Form X.

Long Section Maps. (Form XI.)—These are made in two ways:—Either (1) On the dip

or (2) Vertical.


FORM X
Station Plotting
X = N. co-ord. measured on coord line
Y = E co-ord. measured on lines drawn by test ruler
Plotting by bearing and distance
Contour Plotting

1.—On the Dip—

For this section a plane is generally chosen parallel to the average dip of the vein. The advantages of this are

(1) The actual slope measurements taken in the mine can be plotted on the section map without reduction.

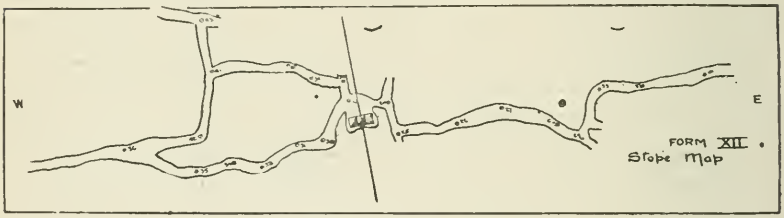
(2) In calculating the cubical contents of stopes, etc., measurements can be taken direct by scale from this section.

II.—Vertical—

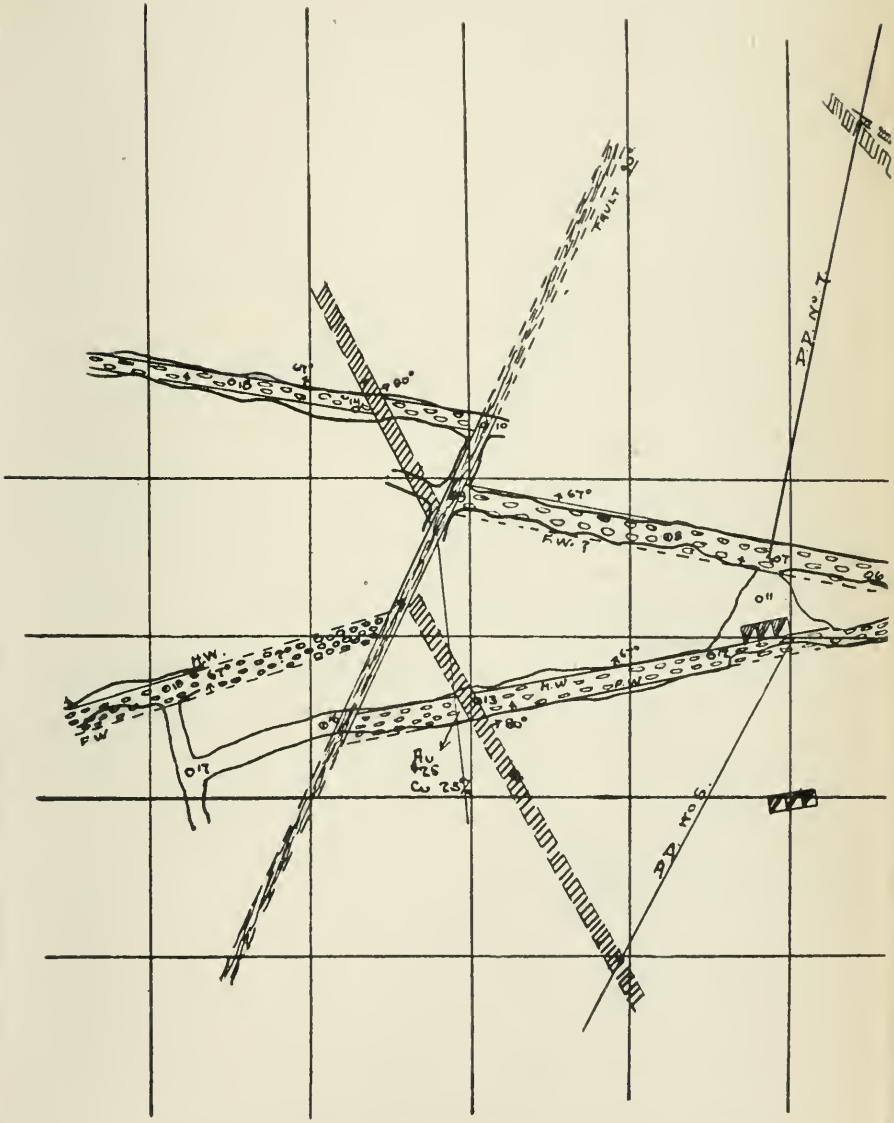
This is a vertical plane generally through the strike of the vein.

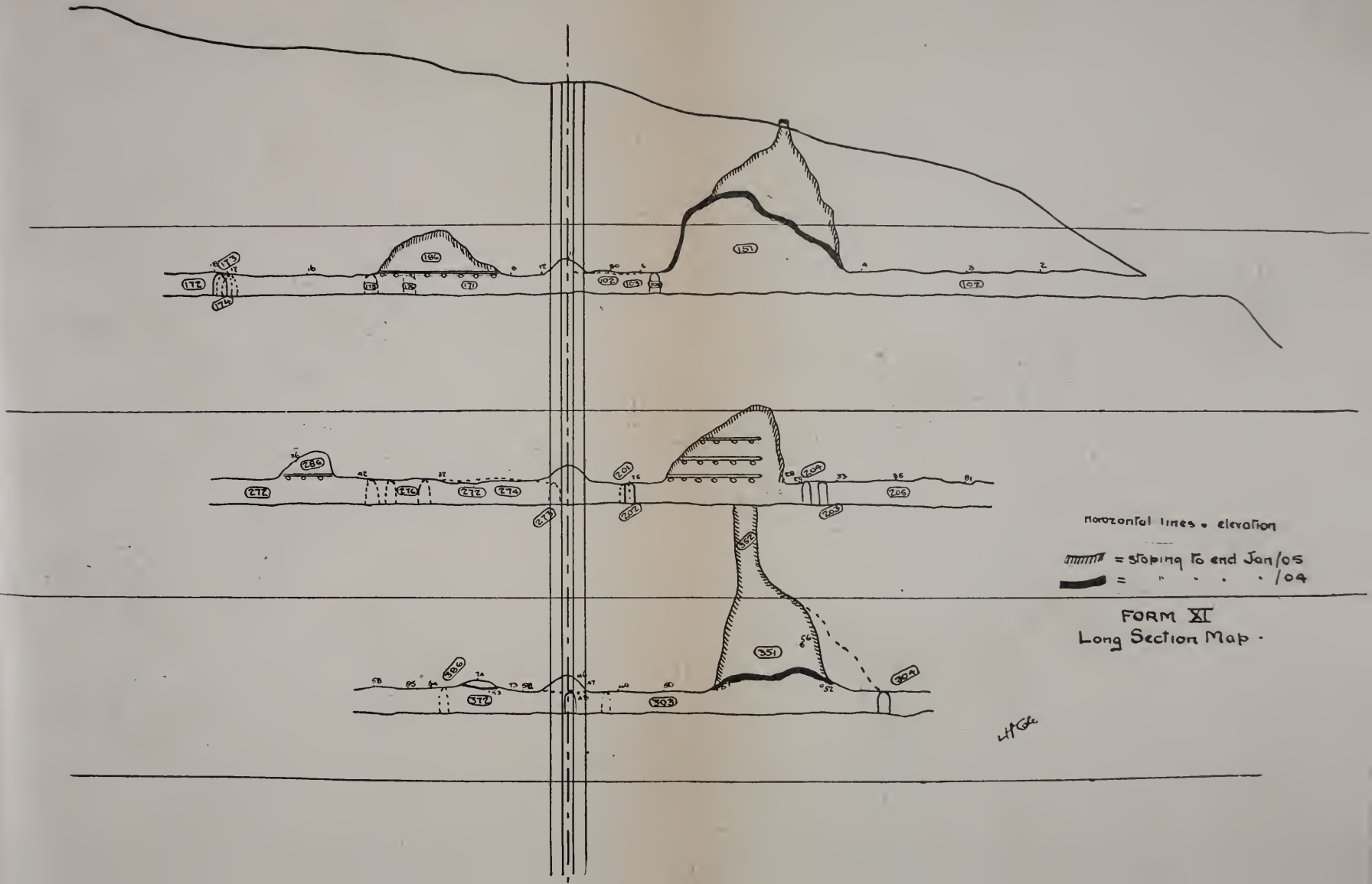
(1) If the vein is very irregular in dip, the above advantages do not hold and then the vertical plane is used.

(2) If there be more than one vein and these at different dips, by plotting these on the vertical, a direct means of comparison is established as actual elevations are here indicated.

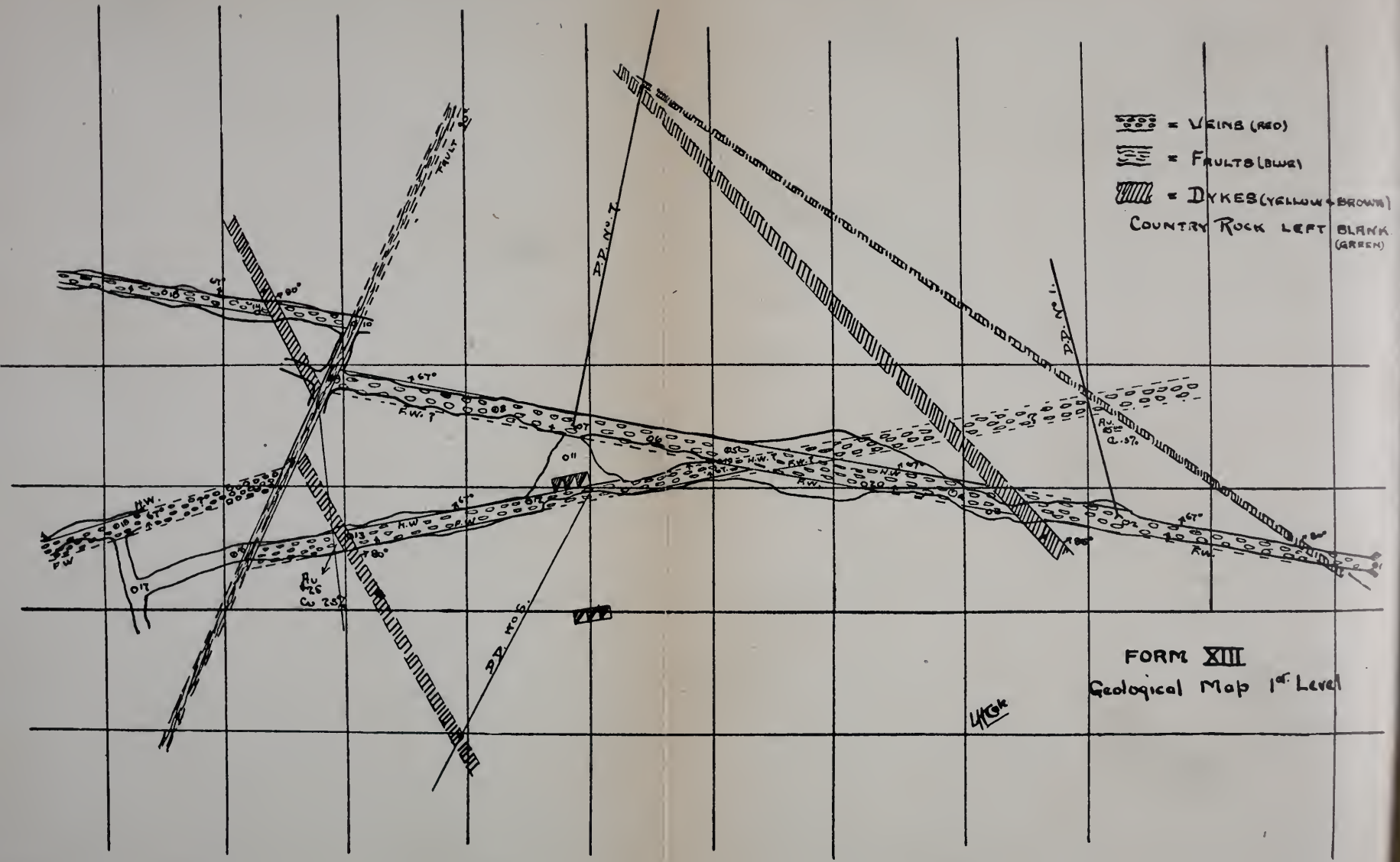


For purposes of illustration three levels of a long section map on a vertical plane along strike of Vein No. 1 have been worked up. On this map all elevations can be plotted directly without change. For the horizontal distances, these are projected from distances on main map. Tracings are made for each level. These tracings are called stope maps (see Form XII). On these are located the bearings and H.D. of all points plotted in the stope. This is done in pencil so as to easily erase it. Then the tracing is lined up by central line on long section map either above or below the stope on which you are working. Parallel lines are drawn through the plotted points to the line of the shaft. The elevation of each point is located on its corresponding line and points so obtained are joined. The stope is thus completed.


FAULT
PP. No 1
PP. No 6.
F.W.
H.W.
Au
Ag 25
Cu 25



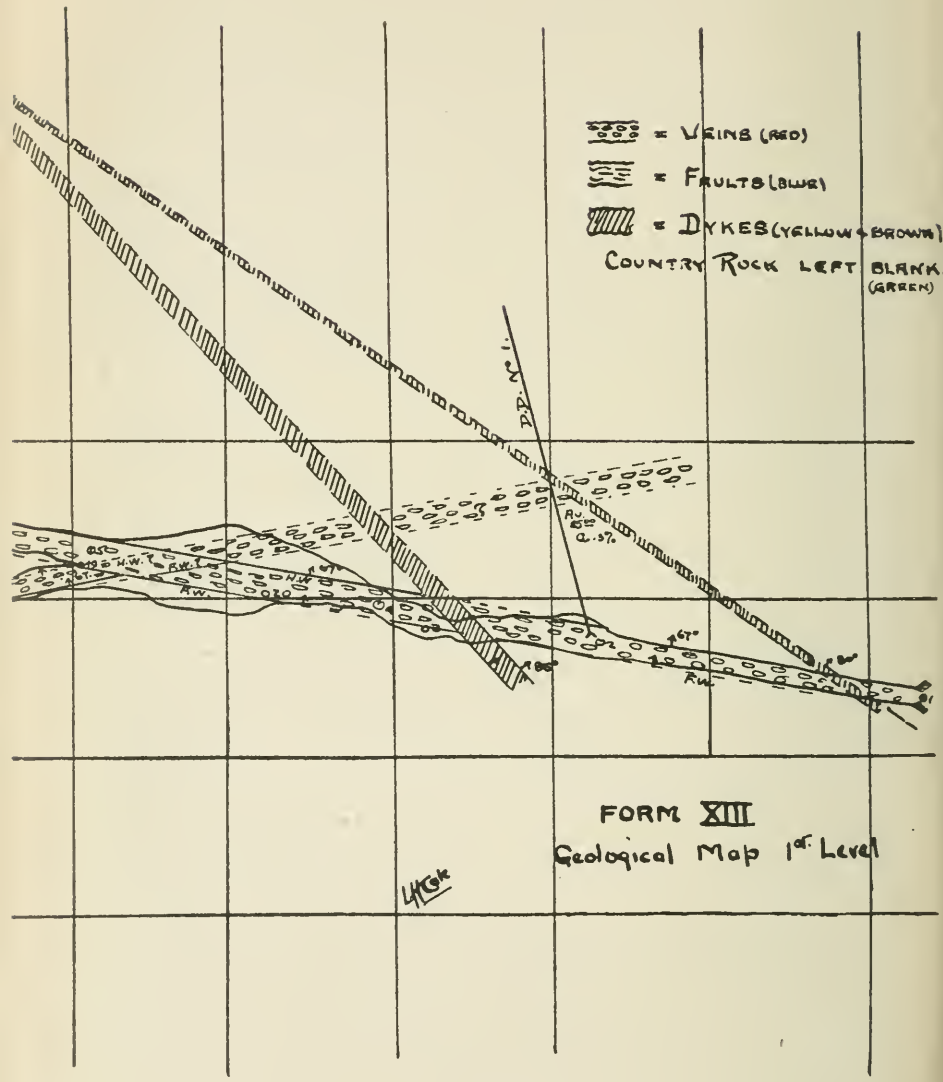
FORM XI
Long Section Map.



FORM XIII

Geological Map 1st Level

L.H.G.K.


= VEINS (RED)
= FAULTS (BLUE)
= DYKES (YELLOW & BROWN)
COUNTRY ROCK LEFT BLANK. (GREEN)
FORM XIII
Geological Map 1st Level

In the case where stopes are located from the square sets the work is much easier. The distances are measured perpendicular and located.

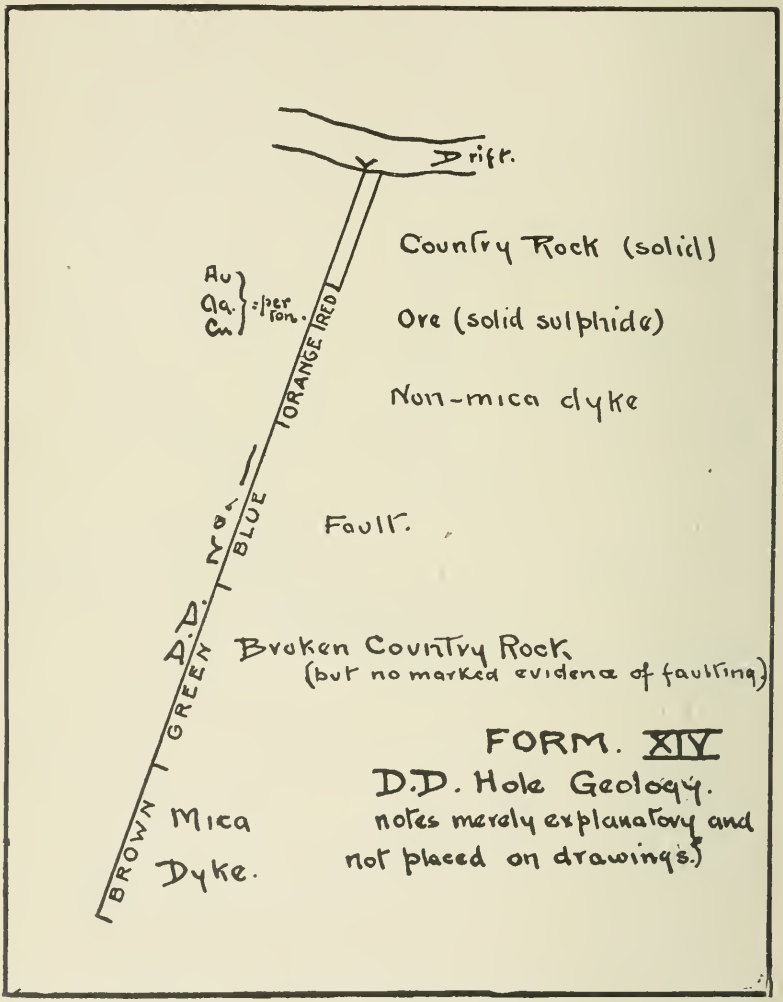
On the long section map certain colours are given to certain levels. The main drift on each level is given a certain colour and when one projection falls on another, the one further away is put in dotted lines and a different colour. The cross-cuts projecting towards the vertical plane, i.e., into foot wall of vein are put in heavy continuous lines while those into the hanging wall are dotted. All stations are marked on this map in the colour of the drift in which they are located. The number of the working is also put in in same colour as that working. A line is put down centre of shaft in red to line up stope maps on. At end of each year the outline of stopes are put in ink (a different colour for each year) so that the amount of stoping done during the year may be seen at a glance. Lines of elevation are ruled across the map in yellow or purple ink at every 100 feet of elevation for facility in working.

When the long section is taken on the dip or plane of the dip of the vein, a table is worked out for values from 1-100 ft. on the vertical and their equivalent values on the plane chosen. This means the saving of a lot of time in reduction of elevation of points.

Geological Maps.—The particular geology of each level is worked up by the engineers and is plotted on tracings from the working map. Each level has a separate sheet. The work underground is plotted to scale on small vellum sheets about 10 by 8 inches. Each of these has traced on it a portion of the level. Thus there are a number of these sheets to each level. They are made to overlap each other. This is worked up twice a month.

When a small sheet is completed it is placed under big tracing and geology is traced through. When level is completed it is carefully examined and details are filled in where intervening geology is obvious. The geology is put in with coloured pencils. Certain colours are used to represent the

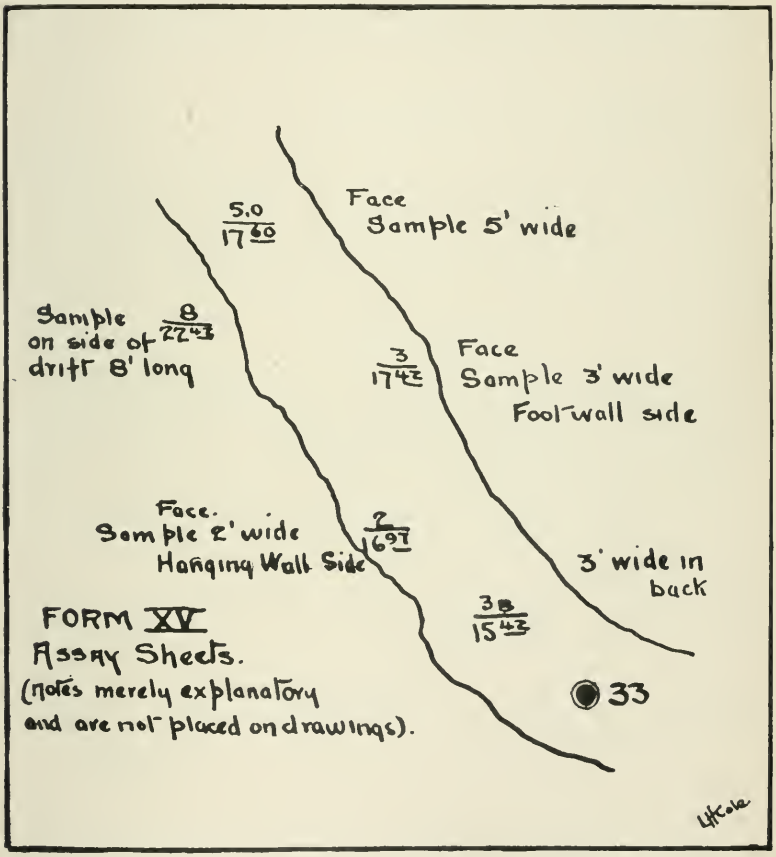
different geological structures, thus the [red] = veins, the [yellow] = non-mica dykes, the [brown] = the mica dykes,



the [green] = the country rock, the [blue] = the faults. The hanging walls and foot walls of the veins are always marked H. W. and F. W. The dip of veins, dykes, etc., are indicated

y —▸ and degree of dip thus —▸ 85° the —▸ always pointing in the direction of the dip.

The diamond drill holes are plotted on these geological sheets and their geology plotted on them. By help of these,



many difficult problems of structure are often simplified. When a diamond drill core assays above a certain value the amount of Au, etc., is stated in small figures at that point. The geology of the diamond drill holes is plotted in similar col-

oured inks to the veins, dykes, etc. The plotting is done by drawing a parallel line close to line of hole and the geology is plotted between these lines. Each change is separated by a black line. When the core is greatly broken the space is dotted. Geological map of first level is shown in Form XIII. and Form XIV. gives method of plotting D. D. Holes.

The stations are marked on this map as is also the collar of shaft.

Assay Sheets.—Every assay is plotted on tracings. These tracings are enlarged three or four times by a pantograph from the working map. Their value in gold, etc., is given and of sample taken in feet. Thus $\frac{5.5}{\$50.00}$ represents $50 in gold in a gold in a sample 5.5 feet wide. The smelter's gross assay value is used. This is gross assay value less indirect charges. (Form XV.) gives method of plotting.

LEDGER INDEX.						REMARKS
⊙ No	Place	Ledger		Note Book		
		No	Page	No	Page.	
1	10z Tunnel	1	27.-82.-84	3	1-63-67 85 97-101	
2	10z drift	1	27-40.-82	3	1-70	
3	10z drift		etc.			

Sample of one method of Indexing employed

FORM XVI
Indexing.

Office Details.—Tracings are kept of all maps both for blue printing and for use outside of office, as originals never leave the Survey Department. A very complete system of indexing is employed (See Form XVI.) so that any information can be obtained at a moment's notice. All notes taken in connection with the mine are indexed for reference. The note books are all numbered and pigeon-holed in the vault; maps are also

kept in the vault on shelves with their tracings. A record is kept of the persons who make each survey. The working map is taken from the vault in the morning and is spread out on its table where it is left for reference all day. These maps are never seen by any but the general manager, the superintendent and the surveying staff. The system is very complete in all its details.

Order of Taking and Using Notes.—Notes taken are first entered in field book. Then computation is made in the office in an ordinary blank book and results are plotted and then entered on ledger sheets.

Ledger sheets are arranged in order and combined and then entered in the ledger. They are then indexed.

DISCUSSION.

Mr. Coates.—I would like to ask about the style of transit used in these mines. At the time at which I was working we found no occasion to use a transit. We, however, used a telescope. I should be glad to know whether the two transits referred to are necessary in making mine surveys.

Mr. Garde.—It would be in shaft work.

Mr. Cole.—There is very little work done by vertical shaft. At these mines they very seldom use the second telescope, though on one or two occasions they did so.

CHLORIDIZING TREATMENT OF NICKEL ORES.*

By F. N. RUTHERFORD, School of Science, Toronto.

The nickel industry in Ontario is fast becoming an important one and different treatments are being sought, in a hope of producing cheaper methods.

The treatment of ores by the Chloridizing-Leaching method is one which has been tried for some time, with satisfactory results, upon various kinds of ores. In the case of copper, for example, this is an established method of treatment, but, as yet, little has been done in its utilization in the treatment of nickel.

As is generally the case with laboratory experiments of this kind, facilities are so inadequate that it is difficult to form a connecting link between theory and practice, but a great deal can be done to show the direction one must follow and in ascertaining wherein the real cause of failure lies or up to what limits the operation may be successfully carried.

This paper does not pretend to be an exhaustive or conclusive treatise on this subject, but is merely an outline thereof, indicating the ground over which the author has worked. An endeavor will moreover be made to point out some of the difficulties and peculiarities which must be taken into account when attempting to obtain nickel as a chloride, preliminary to leaching.

The Canadian ores, being generally sulphides, and containing an excess of sulphur, detrimental to this process, are first roasted. This roasting is done in many ways, but to-day mechanical furnaces are chiefly employed.

The idea of roasting ores with salt, and afterwards leaching them, is not a new one, as it has been applied in silver and copper production for a long time, with varied success.

* Student's paper sent in for prize competition.

This method is known as the Henderson process, and has been used to work low grade pyrite cinder remaining from the manufacture of sulphuric acid. This residue containing the two per cent. copper is roasted with about ten per cent. common salt. The dry cinders are ground with the salt to about twenty mesh size and then roasted. If there is not enough sulphur in the cinder to equal about one and one-half times the copper, raw ore is added until that amount is reached. After roasting, the mixture is leached and the cuprous salt extracted by water. The cupric salt is not soluble unless the solution is slightly acid.

It might be noted here that laboratory experiments carried out on copper ores gave good extractions, and correspond very well with the results of commercial operations; but the best results obtained from nickel ores carried on in a similar method to the above, employing every conceivable modification, gave at the very best only a sixty-five per cent. extraction. This was on a low-grade ore, using the following charge:—

Ore	130 parts, size 1.5—2 mm.
Raw ore	10 parts, fines.
Salt	20 parts.

Experiments along this line were continued with an idea to showing the general effect of temperature on the formation of the chlorides. At first the roasting was done in an ordinary assay muffle. The results were very low, and it was thought to be due to the loss by oxidation of the chlorides which had formed. To render this oxidation practically impossible, the subsequent experiments were carried out by using a sealed fire-clay vessel which prevented the direct passage of air over the contents.

In this vessel the charge was placed as follows:—

Ore	100 grams, under 20 mesh
Raw ore	6 grams, pass 40 mesh
Salt	15 grams.

This charge was roasted for twenty minutes in a muffle, at a temperature of 825 deg. C. At the end of this time it showed no traces of ferrous iron, so the roast was discontinued. After cooling, the product was leached and the liquid titrated with a standard solution of potassium cyanide. The result obtained was only thirteen per cent. extraction. Similar results were obtained under different variations in the size of the ores.

The next experiment was made similar to the previous one, but ferrous sulphate was substituted for the raw ore. This charge roasted for fifteen minutes at a temperature of 700 deg. C., gave an extraction of 30.5 per cent of the assay value of the ore. This charge was repeated and roasted for thirty-five minutes, and the extraction was increased to 34.2 per cent.

The residue from these operations was again treated similarly and a further extraction of 4 per cent. was gained. The final residue was assayed and found to contain 59.8 per cent. of the original nickel.

The temperature was now reduced to 520 deg. C., and the following charge added:—

Roasted ore	60 grams
$Fe\ SO_4$	35 grams
NoCl	30 grams

and the roast continued for thirty minutes, and the extraction was found to be 52.13 per cent.

Using a similar charge, roasted for five hours, the extraction was reduced to 50 per cent.

In this last experiment it will be observed that when the time of roast is extended that there seems to be a decrease in the extraction, due, no doubt, to a slow volatilization of some of the chloride.

The temperature was still further reduced to 375 deg., and an extraction of 47 per cent. gained. In leaching this last product, one-half was tried with water alone and the remainder with water slightly acid with hydrochloric acid, and

the two results were practically identical. Thus, in the case of nickel chloride, the acid solution does not beneficially alter the result as it does in the case of the copper chlorides.

Extremely low grade ores were treated in this manner, and an extraction of 56.2 per cent. was reached, which was the highest extraction gained by this method.

Owing to the low extraction obtained from the previous results, it was decided to look for a cause of loss, and some experiments were tried on pure nickel chloride. The chloride was prepared by dissolving metallic nickel in hydrochloric acid. A piece of asbestos paper was first placed in the bottom of a scorifier and then some mineral wool placed in it. Now 2 cc. of the solution was carefully run into the wool and allowed to evaporate. Over the first scorifier another was placed, and the two sealed together, making the whole structure airtight. The scorifier was then placed so as to be at a constant temperature of 520 deg. C. On examination of the mineral wool after heating, it was found to contain a large number of globules, which proved to be silicates of nickel and were insoluble in water. It might be suggested here, that in all probability, in the chloriding-roasting, silicates are formed by association with the gangue matter in the ores, and forms in this way a loss in treatment by this method.

Acting on some suggestions indicated by previous experiments, an attempt was here begun to find at what temperatures the formation and decomposition of nickel chloride would commence, and by ascertaining this point apply the knowledge to further experimental work. Two methods were tried, one on the chloride itself and the other upon pure nickel oxide. In the case of the chloride, some of the prepared substance was placed in a small boat in a tube which could be heated to a constant temperature. Into the tube a pipe was inserted which led in carbon dioxide from a generator. Leading from the main receptacle containing the boat was a tube connected with several wash bottles containing silver nitrate. The silver nitrate would be changed to a chloride by the chlorine passing from the combustion tube, and the amount

would be calculated when an assay was made of the precipitated silver chloride.

In the first test, carbon dioxide was passed over the nickel chloride, which was heated to 525 deg. C., only 8.5 per cent. of the chlorine was liberated, and on examination the residue showed fine globules of metallic nickel, but the whole substance in the boat was practically insoluble. The second test was carried out similarly to the first, with the exception that the carbon dioxide was first dried by passing through sulphuric acid. The passage of gas was continued for thirty-five minutes at a temperature of 550 deg. C., and only a very faint precipitate was formed in the wash bottles.

This last result would tend to show that even if the chloride is not decomposed, that it does not remain soluble.

The third test was carried out by passing air over heated nickel chloride and the products of combustion drawn through the bottles by a suction pump. When the temperature had reached 390 deg. C. a slight precipitate began to form, and the heating was continued for twenty-five minutes when the temperature had reached 440 deg. C., and the air passing through the tube showed no trace of chlorine. The residue left in the boat was practically insoluble. The assay of the wash bottles corresponded to 30 per cent. of the chlorine contained in the chloride.

The second experiment was made by using nickel oxide in the place of the chloride, and passing chlorine over the boat. The following table will show the results here obtained:—

Temperature	Time	Ex'n of Nickel
200 deg. C.	30 minutes	none
300 deg. C.	30 minutes	none
375 deg. C.	30 minutes	trace
400 deg. C.	30 minutes	10 per cent.
450 deg. C.	30 minutes	12 per cent.
500 deg. C.	30 minutes	decreasing
600 deg. C.	30 minutes	decreasing

The chloride began to form at a temperature of about 375 deg. C., and hence these experiments must necessarily be carried out at as low a temperature as possible. When a temperature of 500 deg. C. was reached, and even before that, the chloride began to volatilize and could be collected in the tubes. The residue in the combustion boat was insoluble.

In the case of some chlorides of copper, it was recognized that by adding some hydrochloric acid a greater percentage extraction was attained. It was decided, upon this assumption, to apply this method here, but instead of adding liquid acid the fumes were passed over the oxide along with the chlorine gas. The results obtained from a large number of experiments carried out in this way were somewhat more satisfactory in producing a higher extraction; but, in this case, as in previous cases, the same limiting temperatures were observed, the behaviour being similar. By this result, combined with that previously obtained by adding the liquid acid to the leach water, it would seem that the addition of acid in either form does not materially alter the result.

Copper has furnished another method of treatment, and it was decided to try some experimental work on nickel by roasting the ore with a mixture of manganese dioxide, salt and sulphuric acid.

The first charge was proportioned as follows:—

Roasted ore	100 grams
Salt	15 grams
MnO_2	5 grams
H_2So_4	10 grams

The charge was intimately mixed and would pass the forty mesh. The whole mass was brought to a pasty condition by the addition of the sulphuric acid. The roasting in the first trial was done in an open vessel, and subjected to a temperature of about 400 deg. C. In adding the salt, a greater amount than the theoretical quantity was used, as a great deal of chlorine will necessarily be wasted. The roast was continued for thirty minutes, and the residue leached in boiling water

and the liquid drawn off. It was found that at this temperature a great deal of the iron was converted into a chloride, and also that the copper was made soluble. In the assay of the leachings, the iron was separated by the basic acetate method and the copper precipitated. The nickel was then titrated with potassium cyanide and an extraction formed amounting to 59 per cent. of the nickel in the ore.

The second trial was made with a similar charge, but the roast was done in a muffle. The crucible containing the mixture was sealed, with the exception of a small opening for a gas outlet. The temperature in this case was kept at about 500 deg. C., and the assay after thirty minutes' roasting showed 39 per cent. extraction. There was, in the latter case, no evidence of the volatilization of chlorides, but there was, apparently, a tendency to form the chloride in an insoluble form.

In conclusion, it will be noted that chloride formed directly by chlorine and nickel oxide begins to form at a comparatively low temperature of 375 deg. C., and when 500 deg. C. is reached it begins to volatilize and form insoluble compounds. It will be noted that in the case of poorer ores that there seems to be more success, and this fact would indicate that there might be a possible prospect of it being a good method on extremely low grade ores.

The process does not seem to be limited to a time factor, as equally good results are obtained by long or short roasts.

The writer is now continuing experiments along these lines and on some others which cannot be embodied in this paper, but it is hoped that these suggestions may be beneficial to future researches in this direction or of value to those whose interests are centred in the Canadian nickel industry.

NOTES ON GRAPHITE, ITS OCCURRENCES, USES AND PRODUCTION.*

By G. C. Bateman.

Graphite was produced in Canada as early as 1846, but, as yet, the industry has not attained a degree of importance commensurate with the size of the deposits. This may be due in part to the difficulty experienced in separating the mineral from its gangue, and also to competition with Ceylon graphite, which is obtained in a very pure form.

Until within the last few years, almost the total quantity of graphite consumed in the United States has been imported from Ceylon. The scarcity and high prices obtaining, however, resulted lately in the opening up and development of the American and Canadian deposits, and the manufacturers soon found that the quality of graphite did not depend so much upon its geographical location as upon its physical purity. A demand for the American product followed, and though no new fields have been opened up, much greater attention is now being paid to the development and exploration of the known deposits. As yet, however, the bulk of the purer grade graphite continues to come from Ceylon, which furnishes about 80 per cent. of the United States' consumption.

The mineral is sometimes found in nature in flat hexagonal crystals, but generally it occurs in massive, foliated, scaly or compact forms. It is greyish-black in color, with an almost metallic lustre, and has a black shining streak. It is composed chiefly of carbon, but usually contains more or less aluminum, silica, iron and lime, apparently as a mechanical mixture rather than as a chemical combination.

Graphite is usually found in the older metamorphosed regions, with limestone or gneiss of the Laurentian Age.

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* Student's paper sent in for prize competition.

In the McConnell property on the Rideau Lakes, the mineral occurs in the limestone and intimately associated with granite, which has no doubt exerted an influence on it. In the other two working properties in Ontario, the bounding rock as well as the intermixed gangue of the ore is crystalline limestone.

Generally the ore consists of flake graphite, thickly disseminated in the limestone, the Black Donald Mine, of Frontenac County, being the only deposit known in Ontario where the flake and amorphous graphite occur together. In this mine the main vein is 7 to 22 feet wide, and averages 14 feet of clean ore. The wall rock, however, contains flake graphite so thickly disseminated as to give a width of 40 feet of workable ore.

Graphite is sometimes found as an alteration product of coal. A good example of this is the graphite anthracite of Rhode Island, where increased heat and pressure have driven off the volatile matter from part of the coal, leaving the carbon in the form of graphite.

Most graphite, however, is the result of heated waters and vapors acting on the rocks within the earth's crust, and the carbon is probably derived from the distillation of oils and from the hydro-carbons of volcanic emanations. At Ticonderoga, N. Y., where the principal deposits of the United States occur, the graphite is supposed to have reached the fissure as some volatile or liquid hydro-carbon, while that found near Travancore, Ceylon, which occurs in a large fissure vein in Laurentian gneiss, probably originiated from the reduction of carburetted vapors.

The continued high price of graphite has led some manufacturers to substitute the artificial for the natural product. This has proved quite a serious competitor, but the great advances made in iron and steel work, the use of copper and its alloys, the development of electrical machinery requiring graphitized products, and the increased need for special lubricants, have kept up the demand for the natural product.

There are two kinds of artificial graphite manufactured in the electric furnace, graphitized electrodes and artificial graphite. In the former the ordinary electrode is composed of a mixture of petroleum, coke, pitch and some carbide-forming material, as silica or iron oxide. This is submitted to the heat of an electric furnace and the whole is graphitized, forming a product having special properties.

In the production of artificial graphite proper, anthracite coal is heated in the electric furnace and the impurities eliminated. Pure graphite possesses very high electric conductivity, has great resistance to chemical action, and has not the property of occluding gases, which is possessed more or less by all forms of amorphous carbon.

The consumption of crystalline graphite in the arts is distributed as follows:—

Crucibles	55 per cent.
Stove polish	15 per cent.
Foundry facing	10 per cent.
Paint	5 per cent.
And all others	10 per cent.

The manufacture of crucibles calls for a very high grade of material, the high refractory qualities and resistance to the action of heat rendering it peculiarly adapted for this class of work.

The need for special lubricants has led to the use of graphite, but the difficulty of getting the mineral pure enough for the purpose has so far limited its use.

One of the most common forms in which we see graphite is that of the ordinary lead-pencil. The lead is formed by mixing clay with a pure variety of the mineral and baking the mixture to the desired hardness. The finest graphite for this manufacture comes from Irkutsk, Siberia.

In the last few years, the great advance made in the use of steel for all sorts of structural purposes has led to the

evolution of many kinds of paints to prevent corrosion. Graphite paints are rapidly replacing all others for this class of work. They resist the action of moisture and of acids, and are not affected by heat—thus making a very valuable preservative for steel, which is not so readily corroded. It is particularly useful in this respect for mines which use steel instead of timbers, as the water there is usually much more acidic and has greater corrodin gpower than in any other place. Foundries also consume quantities of graphite, for there it is used as a facing, thus giving a smooth, clean surface to the casting. There are also many minor uses, as black-lead, etc.

The problem of treating graphite-bearing rocks is one that presents many difficulties. The difference between the specific gravities of the mineral and the gangue is very slight, only about .6, and thus it is very hard to effect a separation. Besides the ordinary methods of concentration (which will be described later) there are two new methods worthy of attention.

One is the treatment of the ore by petroleum vapor, which is absorbed by the graphite, thus permitting it to be rapidly removed by flotation from the gangue, and the other is the heating of the ground product before separation, whereby the graphite is more easily floated off the water while the gangue is carried along the bottom of the flowing stream.

So far, in Ontario, separation has been carried on along two lines, dry and wet.

The first property to produce graphite in the province was the McConnell Mine, at Oliver's Ferry. Here the graphite occurs disseminated as flake in the limestone. The ore was treated by crushing in an ordinary stamp battery, screening and running the product into large tanks. The material was stirred, and then the water, which carried off a good deal of graphite, was run off through an opening in one corner of the tank. After a short time, however, this property was abandoned, and it is only within the last few years that the owner, Mr. McConnell, again started operations.

Before commencing work on the property it was thoroughly prospected with a diamond drill. A number of graphite-bearing zones of varying width were cut by the drill, cent. This value of 76 per cent. carbon may seem small compared to the results previously obtained, but it must be considered that the sample assaying 76 per cent. consisted of the whole non-magnetic material, made up of the different sizes of flake, some of which ran as low as 76.5 per cent. carbon.

The following is the method of analysis used:—

.5 grams of the substance was weighed out into a platinum crucible and this was treated by a blast for about 3 hours. For the first half-hour, the crucible stood upright with the cover off, and after that it was inclined and the cover placed against it to give a draft. Too high a heat was found to be detrimental, as it fused the ash which enclosed some particles of carbon, thus shutting them off from the oxidizing action of the air. The high heat was also found to be harder on the crucible, the percentage of loss being much greater with the very high temperature. A bright cherry heat gave the best satisfaction, and when this was used, the crucible loss was only about 1. millegram in 2 determinations. When the carbon was all reduced, the crucible and contents were cooled and weighed. The crucible was then cleaned and weighed, the difference giving the percentage of ash left, from which the percentage of carbon was calculated.

This method was found to give uniform satisfaction, the results never differing by more than .3 of 1 per cent.

DISCUSSION.

The President—This paper deals with a very important mineral—graphite—which will prove a great source of productive wealth to us some day, as Canada is particularly rich in graphite, which is found through our vast areas of Archean rocks. I will only say that this industry is just becoming one of great importance to Canada, where, no doubt, the deposits

of this mineral are among the richest in the world. I am very glad to see by some remarks in the paper that the Queen's students have the right idea of the volcanic origin of the hydrocarbons. I have no doubt that the McGill and Toronto students will also adopt this view soon, if they have not already.

NOTES ON REVERBERATORY FURNACE SMELTING AT ANACONDA.*

By A. McL. Hamilton, McGill University.

These notes show the growth of reverberatory furnaces used for the smelting of copper calcines at Anaconda from 1890 to 1904 and the effect of the increase of the size of the furnaces on the amount of fuel required for smelting.

The data was obtained at Anaconda during the summer months of 1903-04, with the exception of a reference made to Peter's Modern Copper Smelting, Engineering and Mining Journal for information on the earliest type of reverberatory furnace.

The condition of Reverberatory Furnace Copper Smelting in 1890 was as follows:

The fine concentrates, or finely crushed ore, after being roasted, was charged into reverberatory furnaces through side doors.

The dimensions of these furnaces were:

Hearth area, 9½ ft. x 14 ft.

The hearth was enclosed by a 9 inch fire brick lining, outside of which there was a backing of 4½ inch fire brick, from which the arch took its spring, and enclosing these was a casing of red brick 12 inches thick at the widest part of the furnace and increasing in thickness towards either end.

The grate was 3½ ft x 4 ft., the bridge being

30 inches across.

The cost of such a furnace, including labor at an average of $3.00 per day, was $3,563. To this the cost of the preparation and smelting in of two sand bottoms, viz.: $160, should be added.

* Student's paper, entered for competition and awarded second prize.

The cost of running such a furnace for twenty-four hours, including coal, repairs, etc., would amount to $42.46.

Since such a furnace smelted twelve tons per twenty-four hours, the cost per ton would be $3.54 per ton of ore smelted.

The matte assayed..... 64.5 per cent cu.
The slag carrying..... 0.87 " " "

The small capacity of these furnaces was a serious drawback to this method of smelting, but during the last few years considerable advances have been made in reverberatory practice.

In the year 1901, a plant consisting of fourteen furnaces, having each a hearth area of 50 x 19 feet, was built at the new works of the Anaconda Copper Mining Co., in Montana. At this time, after considerable investigation, it was decided that the McDougall roaster was the best type of roaster for reverberatory smelting work.

This roaster is of the cylindrical type, having a diameter of 15 ft. 9 inches, and a height of 14 ft. It is lined with fire brick. There are six fire-bricked floors through which passes a central water-cooled shaft, to which several radiating arms are attached, all of which are water-cooled. The stirring blades are attached to the radiating arms. The blades are so set that the ore is fed automatically by a hopper on the top floor, where it is thoroughly mixed and stirred by the blades attached to the radiating arms. The blades are so set that the ore is worked from the outside of the roaster towards the centre and from the centre to the circumference alternately on the several floors, openings being left alternately at the outside and centre for the ore to drop to the next lower floor. It is ultimately dropped into hopper bins beneath the roaster from which it is taken while still red hot to the hoppers above the smelting furnace.

No fuel is used after the roasters have been once heated, the sulphur in the ore being sufficient to supply the heat for calcination.

The hot water from the shaft and arms is fed to the boilers in the power plant, thus utilizing the heat.

Electric motors are used for operating the roasters, each roaster requiring 1.3 H.P.

The capacity of the roaster is about forty tons per day.

The analysis of the concentrates fed being:—

Cu	7.5	p.c.
SiO_2	20.3	
Al_2O_3	2.0	
FeO	26.00	
CaO	0.40	
S.	37.1	
Zn	2.2	

The average calcine produced was:—

Cu	8.7	p.c.
SiO_2	29.6	
Al_2O_3	3.2	
CaO	0.5	
FeO	39.5	
S.	7-8	p.c.
Zn.	1.4	

The loss in weight by calcining was about 20 per cent. and about 5 per cent. of flue dust was produced. This flue dust is recovered in dust chambers and in the large flue leading to the stack.

The assay of the flue dust is:—

Cu	8.6
SiO_2	28.4
Al_2O_3	4.2
FeO	32.0
S.	13.0
As_2O_3	4.2
Zn.	2.9

In the construction of the reverberatory furnaces an arrangement was made for preheating the air by the heat from the escaping gases and the heat radiated from the bottom of the hearth. The air was admitted first to a brick chamber built around the pipe which carried the waste gases to the main flue; thence the partially heated air passed beneath the

furnace in narrow channels, passing from front to back four times before rising in a cast iron box to the top of the furnace from which it was allowed to mix with the gases from the fire box through checkerwork in the roof above the bridge wall, the draft of the furnace being sufficient to draw in the hot air. was considered more important to retain the heat in the bottom of the furnace than to use it for preheating the air furnished to the top of the charge, more rapid smelting being accomplished by keeping the matte in the furnace as hot as possible.

In building the plant every convenience to facilitate the handling of materials was arranged for. The ashes from the ash pits are sluiced away by means of the waste water from the concentrator and the slags are granulated and removed to the dump by the same means.

The matte is tapped from time to time into large ladles holding 11 tons and is drawn to the convertors while still molten by means of compressed air locomotives and is then blown for copper. The air necessary for the combustion of the fuel was forced under the grates by means of fans, the ash pit being closed by cast iron doors. Each furnace had an average daily smelting capacity of 100 tons of calcines. The fuel consisted of coal with the following analysis:

H_2O	1.6 p.c.
Volatile combustion	38.7
Fixed carbon	49.2
Ash	10.00

This coal gave very satisfactory results under natural draft, but did not act so well under forced draft.

In former practice the time lost in grating the furnace averaged three hours per day per furnace, and during the grating which occupied one-half hour at a time, the front of the furnace became cooled and the slag frequently set near the skimming door. To obviate this, a larger fire box was constructed to enable the furnace to work without forced draft. The grates were ordinary bar iron with an open ash-pit. The flues and down takes for escaping gases were enlarged. The

results obtained were excellent, increasing the tonnage of calcines treated from 100 tons to 130 tons per furnace per day and smelting 3 tons of calcines to every ton of coal used. Under present conditions the furnaces are kept at an even heat, no time being lost in grating.

The materials sent to the furnaces are carefully weighed in charge cars (20 tons to the charge), the weighing and tramming being done by a set of men entirely separate from the furnace crew. All material is handled by compressed air locomotives and is loaded into hopper bottomed cars which discharge into hoppers above the furnaces. Under the improved conditions of working the costs were very much reduced.

The following are some of the details of the furnace operations:

Draft	1.5in. of water
Analysis of material charged:	
Cu	10.5 p.c.
FeO	39.5
S.	7.8 p.c.
Analysis of slag produced:	
Cu	0.39 p.c.
SiO_2	41.4 p.c.
FeO	45.8
CaO	3.1 p.c.
Matte produced	47.44 p.c. Cu.

Another important improvement was now made, viz.: the installing of a 300 h.p. Stirling boiler between each reverberatory furnace and the main flue, the idea being to utilize the waste heat of the gases escaping from the furnaces. These boilers had been tried before, but they were then installed in the same manner as for direct coal firing, and although the boilers themselves made excellent records, the output of the furnaces to which they were attached fell 20 per cent. below those which had no boilers. In the new setting the idea was to give free passage through the boiler and ample downtake, in order to facilitate the escape of the gases. The furnace thus

arranged gave excellent results, the draft being 1.6 inches of water. The temperature of the gases at the inlet of the boiler was 2380° F., (1304° C.), while at the outlet it was 1100° F., (593° C.), This made a saving of 340 h.p. per boiler, which is equal to a saving of 15 tons of coal per day.

When these furnaces had been running some time it was seen that the heat between the furnace and the boiler was sufficient to do considerable smelting, and it was therefore decided to lengthen the hearth of the furnace to sixty feet. When this furnace was put into operation, it was found by actual running that the tonnage increased from 130 tons to 160 tons, and the ratio of ore smelted to coal used increased from 3 to 1 to 3.7 to 1, which is equal to a saving of 16.7 tons of coal per day. The boiler which was attached to this furnace developed about 350 H.P., or as many H.P. as similar boilers attached to furnaces having only a 50 feet hearth.

It was then decided to build another furnace having the following dimensions:

Grate area	7 ft. x 16 ft.
Hearth area	19 ft. x 83 ft.

Two 375 H.P. boilers were placed tandem between this furnace and the main flue. The results obtained showed an increase in smelting from 160 tons to 202 tons per day, and an increase of three per cent. in the ratio of calcines to coal. These two boilers developed 641 H.P., which is equal to saving 28.8 tons of coal per day. The temperature of the gas entering the first boiler was 2600°F, (1427°C), and entering the second boiler it was 1100°F. (593°C.), and on entering the flue it was about 550°F. (288°C.) These results were so good that it was decided to build a furnace of the following dimensions:

Grate area	7 ft. x 16 ft.
Hearth area	19 ft. x 102 ft.

and to have two 375 H.P. boilers placed tandem between the furnace and the main flue.

When this furnace was in full operation the tonnage increased from 200 to 252 tons, and the coal to calcine ratio was

1 to 4.56. The two boilers developed 720 H.P., which is equal to 32.4 tons of coal per day, the temperatures of the gases being the same as for the 83 ft. furnace.

At the time of writing another 102 ft. furnace is being built. The roof of this furnace is being slightly lowered at the flue end of the furnace to try and reduce the consumption of coal.

It has been decided to build another furnace of the following dimensions:

Grate area	7 ft. x 14 ft.
Hearth area	19 ft. x 114 ft.

From the above it will be noticed that the tonnage and ratio of calcine to coal have increased almost in proportion to the increase of the length of the furnace. Of late the cost of bottoms has been greatly reduced. The later furnaces have foundations made with the molten slag from other furnaces. On the top of this slag the furnace bottom, consisting of crushed silica rock, to the depth of 23 inches is placed. After the bottom has been shaped to the required curves and channels, the furnace is gently heated and finally brought up to nearly white heat, when the silica becomes quite firm. This process takes several days. The first charge consists of silicious flue dust which on being fused, is followed by a regular charge. Careful and slow smelting is carried on for about two weeks when the bottom is thoroughly set, after which it is not liable to come up should a boiling action set in.

The success of saving the waste heat at the flue end of the reverberatory furnaces suggested attempts at economy in the fire box. For this purpose a set of "Hartz jigs" were installed so that the water which carried away the ashes from the aslr pit delivered them into the jigs. After several months' running the average recovery from one furnace having a grate area of 7 ft. x 16 ft. was 11.7 tons of wet coke containing about forty-five per cent. of water,—this would be equivalent to about six and one-half tons of dry coke of twelve per cent. ash, per day.

This coke was found to be of very little value when burned under boilers, but when briquetted along with slimes from the

concentrator, it was found that one ton of this coke in the briquettes saved more than one and one-half tons of coke added in the usual way to the blast furnaces, doing pyritic smelting.

Comparison of Furnaces.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Hearth.					
Date of construction.	1890.		1903.	1904.	1905.
Length feet	50	60	83	102	
Width "	19	19	19	19	
Area sq. "	188	1098	1415	1775	
Grate.					
Length feet	6	7	7	7	
Width "	16	16	16	16	
Area sq. "	96	112	112	112	
Ratio of hearth area to grate area	8.2	9.6	12.6	15.8	
Draft in flue (inches of water).	1.6				
Calcines smelted per day (tons).	130	160	202	252	288
Calcines smelted per sq. ft. of hearth per day (tons)..	0.16	0.15	0.14	0.14	
Coal used per day (tons)....	43.3	43.2	53.3	55.2	
Ration of calcines to coal..	.3	3.7	3.6	4.5	5.06
Coal used per cent. of calcines.	33.3	27.1	27.7	22.2	19.8
H. P. developed	340	350	641	720	
Equivalent wt. of coal per day (tons).....	15	16.7	28.8	32.4	
Coke saved from ashes (per day)	..	..	6.5	..	
Net weight of coal used for smelting	28.3	26.5	18.0	22.8	
Ratio of calcines to net coal	4.5	6.0	11.1	11.0	
Net coal used per cent. calcines	21.7	16.6	9.0	9.0	

Note.—In calculating net coal used, the coal value of the steam developed and in No. 3 the coke saved, are subtracted from the total coal used. The coal used has been stated as a percentage of the calcine to facilitate comparison with blast furnace practice.

Assuming that H. P. is equivalent to evaporating thirty pounds of water at a temperature 100°F. to steam at 70 lbs. gauge pressure and that 1 lb. of coal evaporates 8 lbs. of water.

SOLUBILITY OF COBALT-NICKEL ORES IN AMMONIA.

By GEORGE S. HANES, School of Practical Science, Toronto.

The discovery of nickel and cobalt arsenides in the Temiscaming district renders any discussion on the extraction of nickel and cobalt from arsenical ores a matter of interest. The cobalt and nickel arsenides here are practically free from silica and iron, and require no concentration, and, together with the silver values, average from $1,000 to $2,000 per ton.

The ammonia process of Malzac is probably a new one in the history of nickel-cobalt ores in Ontario, and a thorough investigation locally of this process should be well worth while.

The writer has been carrying on some experimental work by this method of treatment, laboratory results having proved perfectly satisfactory. The process is based on the action of oxygen of the air on nickel-cobalt arsenides, or nickel copper sulphides, in the presence of ammonia, the whole chemical change appearing to depend on the fact that these arsenides and sulphides in the presence of oxygen and ammonia are converted into hydroxides, which are soluble in ammonia. The oxygen of the air replaces the sulphur or arsenic which is combined with the nickel, copper or cobalt, and the oxides so formed become hydroxides in the presence of ammonia. An excess of ammonia will readily dissolve the hydrates and the nickel-cobalt or copper may be obtained by the electrolysis of the solution, or by precipitation of the metals as hydroxides. A partial separation of the nickel and cobalt may be carried on during the process, as the nickel arsenides are more soluble than the cobalt arsenides, and therefore the nickel is mostly dissolved before the cobalt commences to go in solution.

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* Student's paper sent in for prize competition (awarded third prize).

In this method of treatment the ore requires to be finely pulverized. This pulverizing is necessary, in any case, in the ores from cobalt, as the silver occurs in masses, thin plates, threads, etc., and is separated out by screening. The ore may be considered fine enough when it will pass through a 120 mesh screen. The ore is now introduced into a cylinder, or special piece of apparatus, with a filter bottom, so that air may be blown up through the mass. A solution of ammonia is run in, and when the current of air is passed through it the ores commence to go in solution. The filter bottom is arranged in such a way that air may penetrate it at several points and pass up through the pulp. The air, in escaping, may carry off some of the ammonia with it, and if the air is allowed to pass through water, the water will absorb the ammonia, and prevent any loss. When the water has become sufficiently saturated, it may be used for treating more ore. The solubility of the ore depends on the strength of the ammonia solution, also on the amount of air passed through the pulp. The strength of the ammonia solution used has been one part ammonia Sp. Gr. .880 to two parts water, although experiments have shown that if the strength of the solution is increased, the rate of solubility will be increased also. Air under pressure is required so that it may readily force its way up through the mass of pulp and keep it well agitated.

The first ore treated in this way was a pyrrhotite ore from Sudbury, which contains 5.20 per cent. nickel. The ore was crushed, passed through a 120 mesh screen, and put in the cylinder and treated with ammonia solution and air blown through, for different periods of time. The rate of solution appears to depend on the length of time the air is blown through the pulp. The following results were obtained, during one set of experiments, in which the air was passed through for various lengths of time:—

2 hours..... 6.3 per cent. nickel extraction
4 hours..... 9.6 per cent. nickel extraction
10 hours.....40.0 per cent. nickel extraction
20 hours.....87.5 per cent. nickel extraction

The next ore treated was a very rich nickel arsenide from Cobalt, which contained 27.9 per cent. nickel and cobalt, the writer having assayed it by the Potassium Cyanide Method of Titration of Nickel and Cobalt solutions. The specimen was a bronze-yellow color, and appeared to be a very pure nickel arsenide with a small percentage of cobalt arsenide. It contained 1.21 per cent. iron and was free from silica.

After about ten hours' treatment by the ammonia process, the nickel-cobalt ore was completely dissolved, leaving only the small percentage of iron ore behind as residue, or insoluble substance. The solution so obtained was heated, and the arsenic precipitated. The solution of nickel and cobalt hydroxides was filtered off and titrated with the standard solution of potassium cyanide, and the result was 27.6 per cent nickel and cobalt. Thus a complete extraction was obtained. It might be mentioned here that the nickel arsenides dissolve first and form a green solution with the ammonia As soon as the nickel is nearly all in solution the color of the solution changes from green to pink, and the cobalt ore is then commencing to go into solution. In this way the nickel and cobalt can be quite readily separated, although there is no sharp line of division. When the nickel is about all in solution, that green solution may be run off and a fresh one added. A pink solution is then obtained, which contains most of the cobalt.

A smaltite ore from Cobalt district was next experimented with. These cobalt ores, according to assay, contain from 16 to 19 per cent. cobalt and from 4 to 7 per cent. nickel. In treating this in the same manner as the high-grade nickel ore, it was found to be entirely soluble in ammonia, but not quite so readily as in the case of the nickel arsenide. After fifteen hours' treatment the smaltite was practically all dissolved, and formed a very beautiful pink solution. The arsenic was removed from the pink solution, and the cobalt and nickel hydroxides were titrated with potassium cyanide. It was found to contain 25.5 per cent. cobalt and nickel, while the

assay for the ore was found to be 26.1 per cent. cobalt and nickel.

Finding that these ores were soluble in ammonia to such an extent, the writer next tried the process on some nickel-copper matte. The matte was very finely pulverized, and when treated with the ammonia, and air allowed to bubble through it, the copper and nickel sulphides were dissolved very rapidly, giving a deep blue colored solution due to the copper hydroxide.

In using the same amount of ammonia as was required for the smaltite ores, the copper and nickel sulphides in the matte were dissolved in about ten hours, leaving the silica and iron oxides and sulphides behind. The matte contained 39.75 per cent. iron, 9.9 per cent. copper, and 21.1 per cent. nickel. The extraction of copper and nickel was complete.

In all these experiments the ammonia process appears to work perfectly. The pyrrhotite ore being low grade, and large quantities of iron sulphides being present, the rate of solution of the nickel sulphides in ammonia is not as rapid as in the richer ores. Possibly the iron masks or protects the nickel.

Since this method or process gives such a complete extraction of cobalt, nickel and copper, its commercial possibilities should be further investigated. Of course, in a laboratory, the chemical process may be accurately calculated, while the apparatus suitable for tests on a commercial scale may not be very easy to obtain.

For treating the ore on a commercial basis, a large metallic cylinder with a filtering bottom may be used. The ore, after being finely pulverized would be put in the cylinder and the ammonia solution run in. Air under pressure would then be blown up through the pulp, which would cause the chemical reactions mentioned above, and the cobalt, nickel and copper would go in solution.

The air would carry off some of the ammonia gas with it, and this ammonia would be collected by passing the air through water. After a time, when the water becomes satu-

rated with ammonia, the strong ammonia solution would be ready for treating more ore.

When the cobalt, nickel and copper are all dissolved by the ammonia, this solution may be filtered off and the residue washed with dilute ammonia to dissolve any remaining hydroxides. The iron and aluminum oxides and iron sulphides remain undissolved, as the ammonia has no effect on them.

According to the inventors, the solution could then be electrolyzed and the nickel, cobalt and copper obtained, or it could be evaporated to dryness and the oxides or hydroxides obtained.

This process has the following good features:—

1. There is very little loss of ammonia, which is almost totally regained, and therefore the loss or expense in this direction would be very small.

2. The process is perfect in this respect, and in nickel-cobalt arsenides, or nickel-copper sulphides the extraction is complete.

3. The operations are simple, and require very little handling.

4. The process is especially suitable where hydraulic and electric power can be reasonably obtained.

A NEW MINING DISTRICT IN THE NORTH OF QUEBEC.

By J. Obalski, M.E., Quebec, Que.

Until 1900, the northern boundary of the Province of Quebec was the height of land, and the formation was mostly considered as Laurentian.

In 1900, this boundary was extended to the East Main River, and the work of the Geological Survey has shown that a considerable part of that territory is covered by the Huronian formation. The different geological explorers, such as Dr. Bell, Richardson, Low and others, without going to the detail of prospecting, had called attention to the probable value of that northern section from a mineral point of view, but the first real prospect was undertaken by Mr. Peter McKenzie, who boldly started upon such general indications to explore the region north of Lake Chibogomo, where Richardson had first pointed out the existence of serpentine, copper pyrite and magnetic iron. Thus, in 1903, Mr. McKenzie made two explorations there, starting from Lake St. John, and brought back specimens of asbestos, copper ore, magnetic iron, with information of such a nature that I decided to visit this district with him, in the fall of 1904.

I reached the Chibogomo by way of Lake St. John, the River Chamouchouan, and a succession of large lakes called Chigoubiche, Chamouchouan, Nikaubau and Obatogoman, the same route having been followed by previous explorers. After passing the Laurentian gneiss, the first Huronian rock was encountered in the form of diorite, at the end of Lake Obatogoman and followed to the north end of Chibogomo. The formation then consists mostly of diorite rock, but is sometimes chlorite schist, intrusive granite, conglomerate, talc schist and serpentine.

On a large island between the two discharges of Lake Chibogomo, I found the following minerals:—

1. An extensive outcrop of quartz showing a distinct vein of the same, running about E.W. for 2,000 feet, with a vertical dip. The south wall was well exposed and I measured 30 feet across without finding the other wall, the quartz being then covered by earth and trees. This quartz shows visible gold in small particles in several places as well as in the loose boulders; it also contains bunches of copper and iron pyrites in which analysis have shown gold in commercial quantities. By panning out in the vicinity of the vein, and even at some distance from it, fine colors of gold were found in nearly every pan. Several hand pieces of quartz were tested, giving from traces to $10 per ton, two specimens of pyrite giving respectively $9 and $64 to the ton. About 8 ounces of concentrate resulting from the rough hammer crushing followed by panning of about 100 lbs. of quartz from that vein, gave 9 ounces of gold to the ton, numerous colors of gold being visible in that concentrate.

2. An outcrop of chalcopyrite yielding 23 per cent. of copper with some gold and silver to the amount of $2 to the ton. The ore is contained in what is apparently a vein running N.S. from the shore of the lake, of about 2 feet of mixed ore and quartz, some bornite being also met in the vein. In the surrounding diorite rock small pockets of ore are also in sight for a distance of more than fifty feet along the shore. By panning out in the crevices of that vein, which is about one-fourth of a mile from the auriferous quartz vein, I found colors of gold.

3. A belt of the diorite contains a large amount of magnetic iron disseminated through the rock for about 50 feet in width and a distance of one-fourth of a mile towards a hill called Paint Mountain, about 300 feet high.

4. On this Paint Mountain there is a good deal of rusty rock and at one point I found colors of gold. In several places are small quartz veins, some of them with a little copper pyrites, and at a few points, red oxide of iron or ochre, being undoubtedly due to the decomposition of iron pyrites. By digging out at one place a kind of porous quartz was encount-

ered, and a few feet deep, it became impregnated with iron pyrites to the extent of fifty per cent. in the quartz, such pyrites containing 44 per cent. of sulphur, but no copper nor precious metals. I consider that deposit to be a large one.

About five miles in a northerly direction, after passing through some narrows where diorite and conglomerate are visible on both shores, a large exposure of serpentine rock is met with. That serpentine was mentioned by Richardson on a small hill which we called Magnetic Cone, but the exploration of the shore and of the Rapids River shows that this formation extends in an easterly direction for more than 8 miles, and, in fact, I did not see the end of it.

On a large island, close to the shore, Mr. McKenzie discovered asbestos on his first trip, and in the following ones he made some prospects which disclosed fibres of good length, and, in my opinion, in commercial quantities. The quality is comparable with that of our Eastern Townships, the serpentine resembling also that of the same region. I saw fibres of 2½ inches, and at one place there was an agglomeration of veins forming a total width of about 6 inches. The rock presents itself in various forms, being sometimes compact, broken or shaly. When in the compact serpentine, the fibre is very abundant, but the veins do not extend far; in the shaly rock, a variety of apparent fibrous horneblende, resembling Italian asbestos, is quite abundant. The prospects show the existence of asbestos for a distance of about 800 feet.

Magnetic iron appears to be widely distributed throughout this section. On the Magnetic Cone, and in its vicinity, the needle shows a remarkable variation which, in a certain zone, is really 180 degrees turning completely from north to south.

There is a vein of magnesite containing 7½ per cent. of iron, which is magnetic, and the surrounding serpentine is strongly magnetic and contains visible grains of magnetite. On the Asbestos Island there is a black serpentine with a semi-metallic streak due to magnetic iron in an earthy form. In all that district north of Lake Chibogomo, the dip-needle is strongly affected over an extent of several miles, the needle

remaining vertical in many places. The facts are remarkable, and justify the expectation of finding this magnetic iron somewhere in a more condensed form.

I recall the fact that the report for 1872-73 of the Geological Survey mentions a variety of strongly magnetic serpentine found on an island in Lake Abitibi, by Mr. W. McOuatt, which would seem to resemble that found at Chibogomo.

Besides the above indications, magnetic iron in massive form was found by Mr. P. McKenzie, south of the Sorcerer's Mountain in veinlets of about one inch, specimens of which possess the property of loadstone.

On looking over the geological map of the basin of the Nottaway River, by Dr. R. Bell, we see a considerable development of Huronian rocks, having, in the western part of Northern Quebec, a width of about 140 miles from north to south, and I am of opinion, with the members of the Geological Survey who have explored it, that there are great possibilities of finding commercial minerals there. That belt will be crossed by the proposed transcontinental railway, and I think that a large field will then be offered to prospectors.

That district is well wooded with good, but small sized timber, offers numerous water powers, and fairly extensive tracts of cultivable land, the climate being that of our northern countries. The country is undulated, with here and there low hills, and the average altitude is from 1,000 to 12,000 feet above sea level.

DISCUSSION.

The President—So you see, gentlemen, there is a New Quebec as well as a New Ontario. No doubt there is going to be a railway through there before long, and such fine asbestos as these samples now on the table indicate will draw the attention of mining men to that country almost better than anything could do. It only shows how big a mining country our great Canada is, when almost every year there is

a new district opening up; and we are not at all at the end of it yet. We are, on the contrary, just commencing to find our new districts. When we have a few more transcontinental railways we will only then fully realize how really immense our country is.

Mr. Cirkel.—I had occasion to visit recently the asbestos region in the Eastern Townships, and it is surprising to note the progress this industry has made in the last ten years. While formerly asbestos from foreign countries, especially from Italy, was a keen competitor, we find that to-day the Canadian asbestos supplies are practically the only supplies in the world. In the United States there are a great many deposits, but none have been profitably worked. Everywhere it has been found of inferior quality, absolutely different from anything we find in Canada. Some five or six years ago asbestos deposits were found in Russia, presumably in large quantities, but after some mining operations no profitable extraction could be made. It is now a world-wide recognized fact that Canada is the only country which furnishes a first-class article. As to the occurrence of asbestos in the new district, Mr. Obalski has explained this very fully. From what I can see, there are two different classes of asbestos found in that region—the hornblende and the crysotile asbestos, the latter, however, apparently predominating. The occurrence of these new deposits, I may say, make it sure that as soon as a railway is built there that our resources will be considerably enlarged, and that Canada will become the only country—so far known—where asbestos is produced in payable quantities and of undoubted quality.

Mr. Hopper—One always accepts any statement of Mr. Obalski's as correct. Is there any other serpentine beside that mentioned?

Mr. Obalski—The serpentine belt runs for about ten or fifteen miles, and it is of a kind very much like the serpentine of the Eastern Townships. I, therefore, hope that in prospecting closely all through this district one may find sections of it containing asbestos in commercial quantities.

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